# Iron and Steel Engineer

*Established 1907 as Proceedings of A. I. & S. E. E.*

J. F. KELLY, EDITOR

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Entered as second-class matter January 25th, 1924, at Pittsburgh, Pa., under the Act of March 3rd, 1879.
Subscription Price $5.00 per Year. Single Copy $1.00.

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# EDITORIAL

## MAY WE HAVE YOUR SUGGESTIONS?

***In what manner can the Iron and Steel Engineer render greater service to the Engineers of the Iron and Steel Industry? In the following paragraphs we have outlined the aims, objects and scope of the Iron and Steel Engineer. How can we better serve the Engineers of our industry? If you have any opinions or suggestions, please drop us a line.***

The object, aims and scope of the Association is to spread the lights and the truths through publicly distributing its transactions to those interested persons who are engaged in advancing the application of all forms of engineering in the Iron and Steel Industry.

This may be accomplished through publicity, the type and style of publicity, however, that has a real and important function to perform. The Iron and Steel Engineer is the publicity medium for the Electrical, Mechanical, Combustion, Lubrication and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers in which all progress in steel mill engineering is recorded and distributed throughout the Industry.

A little reflection at this time will show the necessity of a steel mill engineering organization such as the A. I. & S. E. E. and a steel mill engineering periodical such as the IRON AND STEEL ENGINEER. Both of these are indispensable to progress and progress in the right direction, in Iron and Steel.

Unless we know day by day, week by week, month by month what engineers and steel mill operators are doing in all parts of our country, we will be like people wandering about in the dark.

The fact that we do know, through the Iron and Steel Engineer, what others are doing, makes it possible to obtain the co-operation of each other for good and worthy objects in the Iron and Steel Industry.

It is also evident that our knowledge of each others activities in our Industry lends us encouragement, moral support in our engineering projects, in our operating problems, especially since we know that engineers and operators are thinking the thoughts we are and entertaining the same projects we have in mind.

The Iron and Steel Engineer makes an earnest effort to bring to the Iron and Steel Industry the engineering news and steel mill operator's news—information that will enable the Industry to keep abreast of the times, to follow developments, to study practices and to avoid mistakes.

The President and Board of Directors of the Association of Iron and Steel Electrical Engineers, who are the executive heads of the Iron and Steel Engineer, solicit your suggestions and your ideas to help them to render a greater and better service to the technical executives and operating superintendents of the Iron and Steel Industry, through their periodical The Iron and Steel Engineer.

### THE STRUCTURE OF THE IRON AND STEEL ENGINEER

**Ownership.**

The Iron and Steel Engineer is owned, sponsored and controlled by the membership of the Mechanical, Lubrication, Combustion, Electrical and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers.

**Purpose.**

The Iron and Steel Engineer is a medium whose aim is to render exclusively to the Iron and Steel Industry an engineering service.

**Editorial Policy.**

1. Editorial matter by engineers, and operating superintendents who have to do with the selection, design, installation, maintenance and operation of equipment used in the processing and production of Iron and Steel.
2. Editorial matter in the Iron and Steel Engineer is, as a rule, not simply the reflection of one man's opinions or experiences, but represents the combined views and thoughts of the engineers who build, who maintain and who operate the equipment under discussion.
3. As an indication and proof of above statement, the October, 1932 issue of the Iron and Steel Engineer contains discussions participated in by 57 technical executives.
4. The author of any editorial matter appearing in the Iron and Steel Engineer must first present his views and opinions before a technical engineering session which may be under the auspices of the Combustion,

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## TWENTY-EIGHTH CONVENTION

### OF THE

# Association of Iron and Steel Electrical Engineers

### JUNE 20-23, 1932. PITTSBURGH, PA.

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**THE BEHAVIOR OF STEEL AT FORGING TEMPERATURES WITH RESPECT TO SCALING LOSSES**—by Dr. D. W. Murphy, Research Associate, Department of Engineering Research, University of Michigan, Ann Arbor, Michigan.

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**DETERMINATION OF MOTOR CAPACITY FOR MAIN ROLL DRIVES**—by H. A. Winne, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

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# DISCUSSION

# Water Cooled Furnaces Steam Boilers*

By H. J. KERR and R. M. HARDGROVE
Engineers, Babcock & Wilcox Company,
New York, N. Y.

Presented before Combustion Engineering Division of the A. I. & S. E. E. at the twenty-eighth Convention in Pittsburgh, June 22, 1932.

DISCUSSION PRESENTED BY

**F. G. Cutler,** Chief, Bureau of Steam Engineering, Tennessee Coal, Iron & Railroad Co., Ensley, Ala.
**C. L. Dudley,** Steam Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.
**G. T. Hollett,** Combustion Engineer, Illinois Steel Company, South Chicago, Ill.
**P. Nichols,** Supervising Engineer, Fuel Section, U. S. Bureau of Mines, Pittsburgh, Pa.
**H. J. Kerr,** Engineer, Babcock & Wilcox Company, New York, N. Y.
**T. J. Ess,** Combustion Engineer, Republic Steel Corp., Massillon, Ohio.

**F. G. Cutler:** Messrs. Kerr and Hardgrove are to be congratulated on the clear analysis of Water-Cooled Boiler Furnaces which is a subject on which much could be written. It is interesting to note that very little reference is made in their paper to the term "% of rating" which was frequently used when blast furnace gas fired boilers were discussed a few years ago, but which term is rapidly becoming as obsolete in steel mill practice as in the utility and industrial field, because of the addition of auxiliary surface to the boiler proper, such as water cooled walls, superheaters, economizers and air heaters.

With reference to discussion of Fig. 30, it should be noted that there is a wide variation in relative power required for steel plant operation, depending on class of material rolled and the extent of electrification of mills, and there is also a wide variation in the production of blast furnace gas depending on number of furnaces in service, type of blowing equipment, coke rate, rate of blowing, gas required for blast furnace use (including hot blast stoves, blowing equipment and auxiliaries), and with the increasing use of blast furnace plant for metallurgical purposes, the power required from coal at the blast furnace plant will probably increase in the future. It is, therefore, not possible to closely compare one plant's practice with another as to proportion of power generated by coal without fairly complete data on practice and equipment.

The method of comparison of boiler furnaces suggested should be more clearly defined if boiler furnaces are to be rated in the manner suggested by Messrs. Kerr and Hardgrove. For example, the B.t.u. release might be taken as the total B.t.u. in the fuel with any heat returned in preheated air in question. The method of calculation of furnace volume should be defined whether total or effective above burners or water screen or ash hopper.

The term **front foot** should be explained; i.e., whether it is the projected area or actual surface of the front row of boiler tubes, or whether any water wall surface is included. Also **cold surface** should be defined as to whether it is projected area of surface covered by water cooling, or actual cold surface with allowance if any to be made for tubes covered by refractory, or other type of protection.

The fusing temperature of blast furnace flue dirt as well as coal used has to be considered, together with the extent of water cooling, when a new boiler is purchased; and it is the object of the steel plant engineer to so proportion the several parts of the equipment comprising the complete unit, as to have maximum return on the investment with minimum cost (including operating cost), knowing well that the capacity attained in operation will in the final analysis be limited by some one or more factors, either the slagging on tubes, capacity of fans or stack, maintenance cost, dryness of steam, or some unforeseen cause.

Installations of combination blast furnace gas and pulverized coal fired boilers have shown this to be a very satisfactory method of utilizing boiler equipment to obtain maximum output with minimum cost, and since it is generally necessary to burn coal to avoid either waste of surplus gas or deficiency in power supply, it is advisable to have sufficient water cooling surface in the furnace to permit maximum rates of operation with coal without having incomplete combustion when burning blast furnace gas alone.

While the last word has not yet been said on this subject, I believe Messrs. Kerr's and Hardgrove's presentation of this paper should be of material benefit in helping the steel plant combustion engineer to decide on satisfactory equipment.

**C. L. Dudley:** The authors of the papers are to be congratulated upon the thoroughness with which they have treated their subjects. There is little that we can offer in addition to what they have given you, and we shall confine our remarks to a few comments upon our experience with combination firing of blast furnace gas and powdered coal.

These boilers are of the B.&W. type, having a heating surface of 24,940 sq. ft. in the boiler proper, with an interdeck superheater. They are designed

*Paper appeared in the August issue of the Iron and Steel Engineer.

to deliver steam at 450 lbs. per sq. in. gauge pressure, superheated to 725° F. total temperature, when using blast furnace gas as a fuel and evaporating water at the rate of 258,750 lbs. per hour f.&a. 212° F.

The boiler furnaces were designed to meet the conditions outlined above. They have a total available combustion volume of 21,000 cubic feet, with a frontage of 23'8" and a total cold surface of 491 sq. ft. exposed to the furnace. No water cooling was used except the boiler itself. The furnace envelope comprises 3,190 sq. ft. of air cooled walls, through which the entire supply of combustion air is drawn.

To provide a source of makeup steam for those periods when a blast furnace is temporarily out of service, the furnaces were equipped with powdered coal burners.

Since the blowing equipment requires about 25% of the steam generated from the available gas, the steam shortage at times of interrupted blast furnace operation is about 75% of normal operation; hence it is necessary to operate the boilers at about 225% of rating when using powdered coal as a fuel.

Since the expected delays on the blast furnaces were of short duration and comparatively infrequent, it was believed that by admitting excess air at such times, that the furnaces designed for blast furnace gas operation at 300% continuous rating would be able to take care of powdered coal operation at 225% of rating. The loss due to large quantities of excess air at these periods would not be great enough to warrant expensive water cooled furnaces.

The fuel gas reaches the burners at an average temperature of 250° F., and contains about 1.0 grain of very fine flue dust per standard cu. ft. The combustion air at the burners has a temperature of 600° F.

When operating on blast furnace gas at 300% of rating the heat release rates per hour are as follows:

| | | |
|---|---|---|
| Total heat release | 330,000,000 | B.t.u. |
| Per cu. ft. of furnace volume | 15,700 | B.t.u. |
| Per front foot | 13,940,000 | B.t.u. |
| Per sq. ft. of cold surface exposed to the furnace | 672,000 | B.t.u. |

No troubles whatever have been experienced with the furnace or tubes slagging. The boilers are frequently operated at 350% of nominal rating for periods of several hours at a time without ill effects.

When burning coal having an ash fusion temperature of 2000° F. at the rate of 225% of the nominal rating, the heat release rates per hour are as follows:

| | | |
|---|---|---|
| Total heat | 247,500,000 | B.t.u. |
| Per cu. ft. | 11,800 | B.t.u. |
| Per front ft. | 10,455,000 | B.t.u. |
| Per sq. ft. of cold surface | 504,000 | B.t.u. |

At this rating we have experienced no trouble with the furnace or tubes slagging, even when maintained for several hours, with careful watching. Here you may see the effect of excessive air permitting us to pass over a period of blast furnace outage.

For boilers using blast furnace gas as a main fuel, and obliged to resort to powdered coal for short periods at such ratings as quoted above, we see no reason for further extension of the cold surface exposed to the furnace if we are willing to accept the loss occasioned by the use of large quantities of excess air during the short periods of furnace outages.

We might quote a few facts from a powdered coal plant, installed in 1927.

These boilers are of the Stirling type Class XIV No. 60, having 19050 sq. ft. of boiler surface with the standard B.&W. superheater. They are designed for 250 lbs. per sq. in. gage pressure with a superheat of 175° F. The furnaces were designed for 300% rating when burning a coal having an ash fusion temperature of 2400° F.

These boiler furnaces have a net combustion volume of 10,350 cu. ft. with a frontage of 30 ft. The furnace walls are of the air cooled type, comprising 1,404 sq. ft. of enveloping surface. The entire supply of combustion air is drawn through these walls.

The cold surface exposed to the furnace is comprised of—

720 sq. ft. in the boiler
225 sq. ft. in the slag screen
110 sq. ft. in the rear wall
1055 sq. ft.—total.

The furnaces proved satisfactory at 300% of rating, when they were evaporating 197,000 lbs. of water per hour f.&a. 212° F.

Under these conditions, the heat release rates were as follows:

| | | |
|---|---|---|
| Total heat | 251,500,000 | B.t.u./Hr. |
| Per cu. ft. | 24,300 | B.t.u./Hr. |
| Per front foot | 8,373,000 | B.t.u./Hr. |
| Per sq. ft. of cold surface | 238,400 | B.t.u./Hr. |

After some little time of operation, a new source of coal was provided. This coal had an ash fusion temperature of 2000° F.

It was necessary to drop the rating to 250% of the nominal when the heat release approximated the following:

| | | |
|---|---|---|
| Total heat | 209,575,000 | B.t.u./Hr. |
| Per cu. ft. furnace volume | 20,200 | B.t.u./Hr. |
| Per ft. frontage | 6,977,000 | B.t.u./Hr. |
| Per sq. ft. of cold surface | 198,600 | B.t.u./Hr. |

These relations are quoted to show their change with a change in the fusion temperature of the ash.

The foregoing opinions on air cooled walls are based upon a standard wall of 10" effective thickness. It seems evident that a thinner wall properly protected against spalling and erosion, may appreciably increase the heat release rates permissible but we can say nothing from the standpoint of actual experience.

**G. T. Hollett:** It has been a great pleasure to read this paper. The author has given a very rational summation of the various steps that have taken place in the perfecting of the boiler furnace of the present time. You will note that in the development of the boiler furnace, the pendulum swings from one extreme to the other just as it does in our economic life. The furnace volume prior to about 1918 was extremely small. You all recall the old type of boiler setting in which boilers of the Stirling type had the lower or mud drum set just above the firing floor and the straight tubed boilers were set so low that a man could scarcely stand up straight in the fire box. The pulverized coal installations, about 1920, shown on figure No. 25, had gone to the extreme in the other direction. The pendulum had gone from the extremely small furnace to the extremely large furnace. From that extreme we now seem to be settling back to smaller furnaces. Part

of this is due to reducing and doing away with the nonactive sections of the furnace and part to the more intimate mixing of the fuel and air by the burner.

The last paragraph on page 25 states, "with blast furnace gas the limit for exit furnace temperature is reached at far higher liberation rates per square foot of cold surface than in the case of pulverized coal furnaces." What do you consider the limit? It seems to me this limit will vary with the type of construction of the furnace.

The development in one particular steel plant as shown as plant "G", "H", and "I" show very clearly the progress made to increase output and decrease maintenance. I am wondering if the next step will be to decrease height of the unit shown as plant "I" by changing to slag top furnaces. This will decrease the building height very materially and lower first cost.

In closing I want to express my appreciation to the author for this paper. We of the Association have another very valuable paper to point out the way to more economical plant design and operation.

**P. Nichols:** Mr. Chairman, there is only one question I would raise. The placing of burners for coal and blast furnace gas in line seems to me in the right direction, and one wonders why that was not done earlier. It seems that it would give both fuels the best opportunity. Has the author any data on the lack of combustion of powdered coal in those furnaces in which the powdered coal burners were placed above the blast furnace gas? One would imagine that the particles would have a poorer opportunity to burn, and it may be that they have data showing a reduction in the combustible in ash loss with the burners placed on a line compared with that when the coal burner was placed above the gas burner.

**T. J. Ess:** I have here some figures put out by Institute of German Iron and Steel Engineers along this subject. They indicate heat release as follows: For gas firing—uncooled walls, 28,000 to 35,000 b.t.u.'s per cubic foot of furnace volume; air cooled walls, 35,000 to 45,000; water cooled, up to 50,000; and fire tube boilers, up to 250,000. With powdered Coal—uncooled walls, 10,000 to 15,000; air cooled walls, 13,000 to 19,000; water cooled, 18,000 to 40,000; and fire tube boilers, 225,000. For stoker firing—uncooled walls, 28,000 to 35,000; air cooled, 35,000 to 45,000; water cooled, 34,000 to 68,000; and fire tube boilers, 170,000. Now those figures are merely offered—I don't vouch for them.

**H. J. Kerr:** The authors appreciate discussion of the paper by Mr. Cutler.

With reference to discussion of Figure 30, this shows only a general situation. It cannot be taken as a definite measure for any steel plant as Mr. Cutler points out, since the use of blast furnace gas for metallurgical purposes as well as the final product from the mill materially affects the values.

The term "B.t.u. liberated" includes the heat in the preheated air as well as the heat in the fuel. The difference in temperature to be obtained in the furnace with preheated air as against cold air is brought out in Figure 29.

The value "B.t.u. liberated per front foot" is obtained by dividing the total heat liberated by the width of the furnace front. In the case of units fired from front and rear or fired tangentially, the value is obtained by dividing the total heat liberated by the double width.

The value "B.t.u. per square foot of equivalent cold surface" is obtained in each case by using a factor for various types of water wall surface so as to put all of these figures on the basis of a square foot of equivalent cold surface. Approximations are made in the paper which may not be exactly correct but are sufficiently near to show the general facts.

The fusing temperature of blast furnace flue dirt is assumed in the paper to be approximately 2300 deg. which also brings up another point of moment which has not been discussed in the paper: namely, the apparent action of some blast furnace flue dust in lowering the ash fusion temperature of the coal ash when both fuels are burned at the same time.

Mr. Cutler also calls attention to the desirability of having such type of water cooling surface in the furnace as to permit of maximum rates of operation with coal and at the same time without having a type of furnace where incomplete combustion would take place when burning blast furnace gas alone. This is a very important point which should have been stressed in the paper and we are obliged to Mr. Cutler for calling attention to it.

In connection with Mr. Hollett's discussion:

The variation in furnaces as brought out in the paper apparently strikes a responsive cord in Mr. Hollett's experience. He asks what the limit of heat liberation per square foot of cold surface may be with blast furnace gas. The answer to this question is that from the standpoint of temperature there is practically no limit. With the burning of blast furnace gas the limitation of a furnace is not too high a temperature but it is the limitation of how much fuel can be burned within a given volume. With this limitation in mind the type of construction of the furnace will undoubtedly play an important part.

Mr. Hollett appreciates the value of the type of furnace shown in Figure 24 as he asks the question as to the possibility of using this type of construction for steel mill boiler furnaces. It might be misleading to answer this question without knowing all of the conditions to be met in any particular case; it certainly can be stated, however, that this type of construction has very definite possibilities for steel mill boiler furnaces of the future.

Mr. Dudley is to be congratulated on adding actual operating data bearing directly on this problem. "The proof of the pudding is the eating of it."

The figures which he gives for blast furnace gas on his B & W boilers are a striking confirmation of conclusion No. 1.

With this same unit for pulverized coal at the rate given, excess air must be used in liberal quantities with coal having ash of 2,000 deg. fusing temperature. The short duration of pulverized coal firing is another explanation of these furnaces giving a satisfactory life. This is one of the factors to be considered in designing furnaces for steel mill boilers.

The data given by Mr. Dudley on the burning of pulverized coal of 2,400 deg. and 2,000 deg. ash fusing temperature on his Stirling boilers are confirmatory evidence of the values given in the paper.

With regard to the comments made by Mr. Ess on the German B.t.u. values, they came rather fast

and I'm not sure that I understood them. My observation is that, when you hear stories from Germany, it is a pretty good thing to analyze them thoroughly before you believe them. Something happens on the way over—the effect of the salt water air or something—that seems to change things a little.

I'd like to call your attention to the method of calculation that Mr. Foltz used in his paper. In that method of calculation he first calculates the heat radiated from a furnace temperature to a wall face; then he calculates the heat transmission from the wall face to the cooling medium, which in his case happens to be air. I suggest that you study this method, because probably there's been no subject in connection with boilers on which there has been so much mis-statement as on water walls, and this method of calculation is applicable directly to water walls and may keep you from being mis-lead.

The authors appreciate the discussion of the paper by members of the Association who have such wide knowledge and experience, as this discussion has added value to the paper.

▲

# DISCUSSION

# A. I. & S. E. E. Proposed Safety Regulations Necessary When Working on High Tension Lines*

Presented before Safety Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 20, 1932.

DISCUSSION PRESENTED BY

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**W. B. Payne:** In setting up regulations for any purpose it is very important that only such rules be adopted as are practicable, such rules as will not be violated frequently due to emergency, such rules as do not retard but rather help in performing the work to be done.

It is almost impossible to draw up a set of regulations which would be applicable to all plants and companies. Some public service companies do maintenance work, such as the changing of insulators on high tension lines, with the lines hot by using live line tools. Public Service line construction in most cases provides for far greater clearances between lines and circuits than is practicable in industrial plant construction. Also there will probably be only one or two circuits of 1/0 or 4/0 wire on the tower line while in many cases in industrial plants a tower line will have as many as four or six circuits of 500,000 c.m. cable. Where live wire maintainance work is done I consider the subject of tools and rules for the use of same most important. Other companies have their lines so arranged that they can clear the lines on which the men are working but not necessarily clear the entire tower. Still other companies insist that all circuits on a tower be dead before any work can be done on any individual line. Of the two last conditions I consider the subject of proper clearances most important.

We have one 44 K.V. tower line approximately three miles in length carrying two three phase circuits; one 22 K.V. transmission line approximately eight miles in length carrying two three phase circuits. Leaving the power house and going directly to the mills are two 6,600 volt tower lines each carrying four three phase circuits. We have other 6,600 volt pole lines carrying one or two three phase circuits feeding sub-stations, etc. We do not allow any work on these tower lines unless all power is off the tower, so our problem is mainly a question of the proper clearing of lines and protection of men against lines being energized, against lightning, static, etc.

*Paper appeared in the June issue of the Iron and Steel Engineer.

The fact that we do not allow men to work on a tower unless all power is removed, often causes postponement of work and shutting down of equipment which we would prefer to keep operating. The loop system which many companies now use and which we are working towards I believe is the solution to the working of lines hot and working on transmission lines with one circuit hot.

I will now cite some of the means used to secure proper clearances. We have placed a sign approximately two feet square at the base of every high tension pole or tower, showing every wire together with the circuit name. The purpose of these signs is to aid the foreman, lineman or any other party so that he will know without doubt just what lines are on a tower and in case of insulator or other trouble he can talk intelligently to the operator. We have found these signs very helpful in several instances.

All poles carrying voltages above 1100 have an enamel danger sign at the base giving the voltage. All poles carrying 440 to 1100 volts inclusive have the cross arm marked with an enamel sign showing the voltage.

At the switchboard we have a general print showing all circuits and the general physical location of the tower lines with reference to important buildings, etc. There is also a separate schematic print of each circuit showing all taps. This print also gives detailed instructions for clearing, calling attention to any sub-stations which might be on and the method of handling this sub-station load. The print also gives phone numbers to call for clearances.

The 44 K.V. line is equipped with grounding switches so interlocked that they cannot be closed until after the main line switches have been opened. On all other circuits ground chains or clamps are used.

The following is the procedure for clearing High Tension Transmission lines. A written order shall be given by the Electric Department for clearing all lines for men working on same and before clearing, at least two competent electric men must go into the field and inspect each pole making a check of the poles and circuits to be cleared. After lines have been cleared at the switchboard, switchboard operators clearances must be checked by at least one competent man. The foreman or other party in charge of work goes to the switchboard and fills out a card (Fig. 1) showing the circuit to be cleared, scope and location of job and location of ground chain.

This card is placed on the control board. The oil circuit breakers and line disconnect switches are opened by the operator and a tag, a duplicate of the one made out by the foreman, is placed on the oil switch and line disconnect. The lightning arrester is then tested to see that the line is clear. The line is also checked with a glow detector when possible. The switching is then checked by the foreman or other party competent to check switching. The lightning arrester switches are then opened and a brass sash chain is used to short and ground the arrester leads and the arrester switches are again closed. This is an absolute check that the lines are dead. The circuit is then reported clear.

On all recent and future construction, removable truck type oil circuit breakers are used making it possible to completely remove the breaker from the bus structure, thus eliminating bus, oil switch and line disconnects and simplifying the clearing of lines.

**DANGER**

**KEEP THIS SWITCH OPEN**
**MEN WORKING ON LINE**

Circuit

| | | | |
|---|---|---|---|
| Ordered Out by | at | A. M. P. M. | 19 |
| Opened by | at | A. M. P. M. | 19 |
| Ordered in by | at | A. M. P. M. | 19 |
| Closed by | at | A. M. P. M. | 19 |

NOTE—This switch can be ordered in only by same man as ordered it out unless he notifies operator that

will order it in.

Send This Card to Chief Electrician After Removal From Switch.

FRONT

**DANGER**

**DO NOT REMOVE THIS TAG**
**SEE OTHER SIDE.**

REVERSE

FIG. 1.

In restoring a line to service the party ordering the line out must order the line back in, notifying the operator that all shorts and grounds have been removed and all men are in the clear. We do not consider it practical for the Department Superintendent to check all clearance switching but rather the General Foreman, Power House Maintenance man or other competent person check the Switchboard operator's switching.

In many cases the foreman calling for clearances cannot check all switching in connection with clearing of a certain line. He must accept the switchboard operators word at other stations, that the lines are properly cleared at the station. He should personally check the testing of the lines and placing of the grounding equipment.

In making out the clearance tags only the foreman's name is placed on the tag. If two or more gangs are working under different foremen each foreman must have his own tag placed on the circuit.

All lines above 440 volts must be chained and when practical both sides of where men work must be chained.

In connection with lines carrying 440 volts we do not consider them in the same class as high voltage lines. Linemen can work very close to 440 volts in perfect safety. Also in most cases these lines do not originate from the power house but from sub-stations and the loads are usually such that the lines can easily be cleared if necessary.

Two other regulations which we felt should be incorporated in our rules for line work are as follows:

No work shall be permitted by any department except the Electric Department to within six feet of the bottom arm on any pole carrying electric wires regardless of voltage, unless all circuits are clear.

Work by other departments can be done from the ground to within six feet of the bottom arm by permission from and under the supervision of the Electric Department. This order applies more to low voltages than to high and for such work as painting of poles and renewing of guys. If even low voltages are on, linemen handle all work from the top to six feet below the bottom arm.

An electrician shall go up on each and every pole, tower or bracket before any other workmen. He shall make a test by grounding by an approved method each and every wire to prove the lines are dead. Other workmen shall not go up until electrician has come down and reported to, and satisfied workmen, lines are clear. This is for the protection of painters, boiler makers, riggers, etc., who have no knowledge of electricity or line construction. If this workman from another department sees an electrician ground and handle the lines on the pole where he is going to work, he is satisfied, otherwise he must take the foreman's word that the wires are dead and he is very hesitant about starting to work.

**J. A. Voss:** Mr. Chairman and gentlemen, I am indeed happy to learn that the Association is preparing a set of safety regulations for the protection of men working on high voltage lines in industry. Most of you men know that we have had some very serious accidents in industry from this source. As Mr. Hunter just mentioned, the rules as set up in the June issue of the magazine are subject to revision. I am preparing a set of rules along these lines for our entire corporation, and I have been confronted with problems in many instances similar to those brought out in the discussion of the subject today.

I recommend to the Chairman of this session that the discussion held here today on the subject be given serious consideration and that a committee be appointed to set up a practical set of safety rules for handling high voltage in industry. I feel satisfied that such rules will be a wonderful contribution to industry; and, if we can assist in any manner, I want to assure you that we will be glad to do so.

**J. Roy Barefoot:** I don't know that I have a whole lot to offer. We have been using a grounding chain, but found by a series of tests, that the resistance of ground chain is rather high, especially if it is not under tension, or if it becomes at all corroded. To offset this objection we equipped one of ground chains with a flexible copper cable interwoven through the links. This reduced the resistance to a point where it is safe to use for a grounding medium, but it is very cumbersome and the strands of the copper cable break and stick out, rendering the device very difficult and dangerous to use.

I think that the solution to the grounding problem is the use of grounding switches permanently installed and interlocked with the line disconnecting switches. Chains and other portable grounding devices are more or less cumbersome to attach, especially where five or six circuits on the same pole must be grounded. Another bad feature is that it is not always possible to obtain a good ground connection in the field, on account of the slag and cinder fills, which abound in our steel plants. I really think that the grounding switch is the safest method of them all and should at least be considered on all proposed new installation wherever practical. I realize that it is not practical to install grounding switches on many of our old circuits, and that in the meantime it will be necessary to use some other device. We have recently purchased a set of grounding devices of the clamp and cable device, but have not used them long enough to determine their worth.

**A. N. Cartwright:** Where you are on wood your short circuit is the most essential thing. If you are on steel, you have the best place to ground right on the steel itself. If you are working on wood, grounding is not nearly so essential, as a short circuiting. If you are on a steel structure, the simplest thing to do is to clamp the grounding cable to the steel structure. That gives the best protection and is the simplest and easiest ground you can make.

**W. B. Payne:** Mr. Cartwright just said that where you are on a steel structure you have the best conditions, or ideal conditions, for grounding. We have found several instances in our own plant where men have been shocked from the bases of steel poles, due to the fact, as Mr. Barefoot stated a few minutes ago, that the poles are set on top of a slag fill. On practically all of our poles at the present time, that is steel poles, we have dug down, in some places twelve or fifteen feet and then driven a rod on down, until we hoped at least to get through the slag filler or to where it was at least damp to get a ground. So, we must find some good way of getting a ground regardless of whether we are on a steel pole or a wooden structure.

Another thing I would like to have somebody explain is the handling of these ground clamps which some of the companies use. We have one set of clamps—in fact, we have two sets in our department—which we use but which are always applied where we are absolutely sure that the lines are dead. I would like to have somebody explain to us just how they would handle that if they were in doubt as to whether the lines were absolutely clear or not, —say they are out a long way from the station and there is a question regarding the clearance of the lines.

**W. R. Hamilton:** The subject is one in which I am very interested. It is not only my vocation but it is also one of my hobbies. I often spend a week-end or evening at home working on some of our rules, studying and revising the material already written or developing something not as yet covered. Such work has to be done continually if an operating code is to be kept up-to-date.

According to this subject of "safety" whether it be covering electrical or mechanical work, I have found four fundamental things I would like to em-

phasize: first, the operating code; second, a capable personnel; third, an educational system; and fourth, supervision.

**Operating Code**

An operating code is not something that can be written by an office man. It is not something that can be written by a young engineer. It has to be written by a man who has a practical background. This man will have to spend a large amount of time on the job. The operating code will not be written once and be satisfactory. It will have to be written and rewritten, cross-checked by department heads. Generally after the material has been written and revised about five times it will be in satisfactory form for issuing. It still will not be perfect. I don't want to scare you as to the amount of work ahead on this task, but I do wish to impress upon you this work is a development and takes time. However, it is time well spent, as the whole background of any safety system is the safety or operating code.

The strength of an operating code lies in its completeness. A code should be so written that it will never be violated. The rules must be backed by discipline which will be enforced. The code must be written so that it will apply to all conditions, both normal conditions and emergency conditions. If the organization finds that short cuts are being taken, either the short cuts must be eliminated, or the code must be revised. Any half-way measure in the interpretation of a code is not safe. This is the whole background of any safety system. The code is really an operating bible and it must be thought of as such. It must be drawn up so that it can be revised easily and I mean by that that it should not be a tightly bound volume. It should be in loose leaf form with a method of indexing so that as practices change the whole code does not have to be rewritten to take care of the changes. The index should permit inserting sheets covering the changes and removing sheets covering obsolete practices or conditions no longer experienced.

When I refer to an operating code I am talking about operations as a whole. The operating code of the West Penn Power Company is the company's operating bible. It is a big volume and the general subject of safety takes up just one chapter; while the safety tagging system takes another chapter; rules covering switching procedure takes up a third chapter. Each chapter covers its subject completely and in detail. There is no reason for any body ever to violate this code as it is kept up-to-date and the rules are drawn up and provide for both normal conditions and emergencies. The code has a loose leaf binding without the pages being numbered. Special indexing is used so new pages can be inserted at any point.

I agree that the details of such a code as we have would not be applicable in all companies nor on all systems. The code would have to be altered in each case, but the fundamental principles that are in our code book are just as applicable to any industry or to any other utility as they are to ours. It is only the method of application that would be changed. I think practically all the electrical industries of the country have basic safety rules identical with ours. Most of these companies worked out their practices independently and it has only been within the last few years that we have been getting together and comparing our methods to find that our practices are surprisingly similar.

The whole subject of operation unfortunately does not have a background which has been covered by any written material which we can use as a ready reference. There is no satisfactory handbook on the market which covers the problem of operation and safety. There are plenty of handbooks discussing the lines, discussing electrical installations and maintenance but I know of only one book published on operation which is in a language an operator can understand. It has not been suitable for our use.

**Personnel**

Our safety training will cover the employes we now have in our organization. Most men are so flexible that they can be trained to carry out the safety code and this training is one of our responsibilities.

Before training our operators, we have to know that they are suitable for handling the job. We cannot assign a man to a job and expect him to learn the job from his buddy. His buddy may be jealous, he may be a man who is not naturally a key man and won't learn. The new man may be a man who will not ask questions and therefore he will not learn much of his failings, unless ways are worked out to teach him what he should know.

**Education**

A code is meaningless if it is not read and understood by the organization and means should be worked out to make sure that this is done. This is very important! The men must know the code, although it need not be memorized. No one is capable of memorizing a volume like ours. Although I have written most of our code, I do not know it by memory but I have the material so indexed that I can find any rule I want. The men in the organization also have learned the code so they can find the rules covering each subject or equipment.

Men who have only occasional contact with operation must be trained as well as the men who work with the operating rules. The working out of this problem is a difficult one.

A supervisor who is directly interested in seeing that he gets across to the men their job and their responsibilities will hold get-together meetings with these men continuously. Such meetings should be attended occasionally by key men from headquarters to see that supervisors and foremen are getting across to the new men these subjects as they should.

**Supervision**

The checking to see that the men do not short-cut the rules and to see that the application of the rules at different stations and covering different work are not violated is an important task. Mr. Henderson brought out a thought which covers this idea. We have along all of our highways "Stop" signs at various crossroads. We all know that the state patrol is checking to be certain we obey these signs. The signs would be of little value if the orders were not enforced. The code is meaningless if it is not enforced, even to firing an employee, if necessary, when we know he continues to violate deliberately the code as he is not a safe man.

I was interested in Mr. Hughes' comments. I agree with all of them. He pointed out weaknesses in the recommendations presented.

When we train men we want not only to tell

them what they should do; we want to teach them why they are required to do certain things.

The best man is the man who thinks as he works. The best operator at switching is the man who knows what switching is being performed at other points on the line and why the switching is being performed. One of our strictly enforced rules is the rule that the load dispatcher when removing circuits from service cannot arbitrarily issue an order to an operator without giving the operator the reason for the order. There is no emergency which is so severe that orders must be executed so quickly that some explanation cannot be given. The operator is given the status of any equipment at any station connected to the circuit. The operators and load dispatchers check with each other during such switching because no man is so perfect at issuing and executing orders that he will not make mistakes which possibly will be caught by this checking system. All operators taking part in any switching hear all orders given to the other operator. If an order is given for switching on the wrong line, an operator often catches it before an error is committed. I find that by keeping all operators informed, they are able to work more intelligently. These practices were brought to my mind by Mr. Hughes' references to his four-station system. We would so tie the four stations together with the load dispatcher that the operator at each station would hear the orders to each other operator and they all would work as a combined unit, not as individual units.

Of course, the communicating system must be laid out to make this possible.

It is necessary to give protection to men at work, but when lines are turned over to them to work upon, this alone is not sufficient; the workmen should also protect themselves. Our line superintendents have told me that if I should release from service a line to a man and fail to perform my switching properly, this man will have taken such precautions before he contacts with the supposedly "dead" line that he would not get caught. The linemen have devices with them which they use to protect themselves. Linemen must ground and short all lines themselves although we also ground and short circuit these lines at each station. I recommend that we be not satisfied just with station grounding but all workmen also be required to protect themselves by placing their own grounds and short circuit on each line. Where only a poor ground can be obtained, a short circuit on each line should be sufficient.

A very good device which can be used for detecting voltage and applicable to 2300 volts and higher voltages is a live line detector known as the "Glowtector". We furnish this device to each substation and to each substation maintenance crew. The operating men are expected to check every circuit for potential before they ground or short circuit the circuit even though they may have performed all switching to de-energize the circuit or have received definite reports from the load dispatcher that the circuit is de-energized.

A man can by careful testing with a disconnect pole having a metal tip, check for voltage on any line of 25 KV or higher voltages, but only an experienced man can make this test and distinguish between an energized line and certain lines which carry heavy induction from other lines nearby, but the test is a practical one.

One difficult application in the applying of our tagging system was the tagging of visible openings. We had to design several devices to attach safety tags to various types of disconnects and disconnect blades and disconnect jaws. We have found it is not a safe practice simply to tag the breaker as an indication that the circuit the breaker controls is released from service. We may want a man to work on a breaker and at the same time we have someone else working on the circuit the breaker controls. The visible opening between the breaker and the line should be tagged in each case so that both men can work independent of each other. The tagging devices we are using are simple things and are not costly but they are essential in the carrying out of the fundamental plan. The point of protection between any energized circuit and any de-energized circuit is always considered as a visible opening. Any breakers between the two circuits are considered as being open, simply so that the visible openings can be obtained. We even tag control fuse receptacles when the fuses are removed for checking by inserting a dummy fuse with a tag attached or in the case of high voltage fuses by tagging the fuses themselves after they have been removed. We know then that no one is going to insert the regular fuses until it is safe to do so. This dummy fuse is another simple device which has proved valuable. None of these tagging devices are original with us. I copied the ideas from other power companies. You are welcome to copy any of them or to make use of any of these ideas.

I noticed your recommended code states that safety tags to be used should contain several names, and the name of each man should be scratched off as he reports clear. I consider it a better practice for each man to have his own tag. Each man, if capable of working on a line should be capable of taking his own release on a line. The organization will be much stronger if the men do not always have to depend on their foremen to get circuits out of service to work upon, particularly if the foreman is not going to remain at the location of work. Sometimes the men may be several miles distant from where the foreman is—depending on him would cause many unreasonable delays.

We have not deemed written switching orders and written work requests necessary. Orders issued orally, if repeated back—and they must be repeated back and checked O.K.—have been found practically as safe as written order. I know of several cases where errors have occurred with the use of written orders which would not have occurred if oral orders had been used properly. True, many mistakes have occurred when oral orders were used but a system can be worked out following the giving of an order, a careful check on the order as given and a recheck which if followed will be just as safe and much speedier than the written order. It is difficult to enforce the use of written orders during emergencies and written orders are only going to be used for normal operation and oral orders are going to be used during emergencies the fact is that the written order is not a safe one.

**L. A. Terry:** Regarding the grounding of steel

poles which are set in concrete and possibly in a slag fill:

We dug down to moist earth and attached a buried artificial ground to the base of each pole, then tie the poles together electrically with a ½" messenger wire. This providing an adequate ground on every pole.

We are eliminating the use of ground chains for various reasons. Most of our high tension circuits are composed of heavy conductors, two main lines having five 500,000 C.M. cables per leg of a three phase circuit, which amounts to virtually two high tension buses running the length of our works. At the power house, the relays on each circuit are set for 3000 amperes.

This kind of a circuit necessitates a grounding device of high carrying capacity. We have found that if the power is thrown on a circuit which is shorted with an ordinary ground chain, that the chain would blow like a fuse, and would not even trip breakers at the power house.

Besides, the induction currents set up in the dead line, due to the proximity of adjacent circuits carrying heavy current, cause the ground chains to get hot and men working on the dead lines a little distance from the chains, claim to have received slight shocks.

We, therefore, designed a grounding device mounted on a pole top and located so that men working on the lines would have a grounding device on each side of them. The conductors of each phase are tied together with a copper bus; on this bus is mounted large copper switch jaws. On the grounding device, are mounted large copper switch blades which slip into the jaws when the grounding device is dropped. These blades are tied together with heavy copper bus and grounded with a copper jumper wire to the pole.

The grounding device is raised and lowered from the ground level by a handle and bell crank. When not in use, the handle is "Locked Up."

When ready to use the device, the man in charge obtains the key from switchboard operator, unlocks the device, lowers it and locks it down with his own safety lock. This arrangement eliminates the possibility of anyone raising the grounding device, except the last man to remove his lock.

We are installing such devices on all of our 6600 volt circuits.

**D. C. Hopper:** There have been several things brought up on which I thought I might be able to give you something of interest. I think you men are approaching a problem that the utilities approached some time ago when we were small. Today utilities are spread over counties and states where your plants cover acres. The Duquesne Light Company System has about 600 miles of circuit transmission lines, excluding everything below 11,000 volts. I imagine Mr. Cartwright's system is perhaps three times that in transmission line mileage. If we attempted to install devices on each pole so we could ground at each pole, and if you multiply the mileage by about thirty you'd get some idea of the number of devices on structures we'd require to provide ground protection on every structure.

I want to emphasize the fact that when you draw up a code for your men to operate under, a code that will be very rigid, you can't start violating that code under any condition. If you do, you void the safety element of the code. It will, therefore, be necessary that when you install this code it be rigidly adhered to; so care should be exercised in formulating such a code or system of ethics.

I realize, also, that you consider high voltage what the utility companies normally operate hot. In other words, from 5000 volts and below, or in some companies 7500 volts and below, we don't attempt to take those lines out of service. All the work is done with the line hot. Facilities are built on the pole so that clearances can be had for the man working with his rubber protective equipment.

One of the difficulties we have is the continuous changing of our lines. We have a line of some number today and tomorrow it's some other number or name, feeding other customers. We have a continuous change. The problem you have is to keep your personnel educated to these changes, and that can only be done through some central operating system, with all changes registered or recorded in that office. Tomorrow the man attempts to report on a line or has to work on a line which doesn't exist because of a change. It existed up to the night before at six o'clock, and he came back the next day and found the line name changed. Your numbers are to change on the line, your station numbering is to change; and that, maybe, occurred at six o'clock last night and the man comes out the next day to work on it and he has to know about those changes. That is an overnight or, you might say, an instantaneous change from one line or number to another, and the man certainly has to be familiar with his lines. He's got to go out and know the line he's working on. He can't take chances.

We've got another problem in the automatic substations without operators. I was very much interested in Mr. Hughes' discussion. I feel, personally, quite interested in the operation of his system. If Mr. Hughes had four automatic sub-stations connected to a line, and that is the problem the utilities face, his method of safety protection would be different. Now the man who operates those stations or clears those stations is really a traveling man. One man may operate one or two of them and another man two or three others; and they must all be reported on. Then, we may have three persons report on a line and two of the men report off and the third man goes home and doesn't report off; what are you going to do? We have made it an irrevocable rule that a line cannot go into service until every man reports off. As yet we have never had a man die between reported on and reported off, but we have had instances where we have hunted all over town and found him at home before we could get the line put back in service. And we have never yet, to my knowledge, put a line back in service without everyone having reported off. I think in one case we got a man out of a moving picture show about seven in the evening to report off. So that is a man problem we have to face, especially if your system is large.

Underground lead sheath cable brings in another problem, and no doubt you men will be facing that in the future—the lines cease to be aerial and become cable lines, and your code should be drawn up so that it can be expanded into cable lines. And

when you come to protecting a man working on them, you still have another problem. You can't draw a ground chain over a lead cable and provide any protection. I think Mr. Barefoot struck the keynote, especially in the cable system, when he stated that all possible grounding devices should be provided at the sub-stations, so that when your line is cleared for the workman it is also effectively grounded.

Then Mr. Hamilton, I believe, pointed out that the man must protect himself. In other words, he goes out to work on the line after he's been properly reported on it, and he must be equipped to do his work without injury to himself. That requires a familiarity with the equipment he expects to work on. Now your ground chain—I mean by that just a common weld chain or whatever you might use—is largely for the purpose of identifying that he has a correct line. Through a rope he draws this chain over the line to make sure that that piece of equipment is dead. I don't think any person using the ground chain feels that the chain is complete protection to the man working on a line. I'd say your second step there would be to place your short circuit and grounding devices—your cable clamp with your conductor big enough to open your circuit breaker, depending on the size and setting of your circuit breaker. Then your three phases should be grounded if you can secure a ground, but at least your three phases should be short-circuited on both sides of the workman. That gives protection to the man. There are various places where cumbersome protective equipment is hard to get, and you'll have to watch that in case of emergency where you have a man work out somewhere on equipment and he doesn't have all this paraphernalia with him. Your code of ethics should be flexible enough to provide for such emergency without violations.

**C. E. Sankey:** Well, gentlemen, I'd like to have the young men who came from the West Penn Power Company give you that code regarding which he said there were four points, including personnel and that is a word I do not like "personnel", education, and supervision.

Why are you here? To learn how to save life! The greatest thing there is to electricity today is the human element, and the human element is the one that comes down when you say—personnel. The men who, today, are killed or fatally injured are not just the ones who don't know. Some of them are men for whom the alibi is given—"Why, he was the best man we had." And then there is the man who is ignorant of it altogether.

There is no man who works with electricity who can say that 110 volts is not dangerous. If he does, he bluffs himself; for the fact is that fatalities have occurred from that voltage but they are not numerous, and so men go on saying—"Oh, I don't have to worry, I can attach a hot one at 220" or "I can," perhaps, "get it at 440." And the first thing he knows some old timer that's learned it, not by reading a book or at college, it's a knack of his, imitates him and runs the risk of death.

The superintendent of a department or general foreman in the manufacturing department is there because he knows all about the working of that department. No man would hold that position unless he were familiar with the unsafe conditions; therefore, he is chosen as the superintendent of men.

In every plant today each and every superintendent and engineer has a different opinion as to how things should be done. You have heard the discussions here today. Some will say chains; some will say clamps; some—no ashes; the other fellow says—ashes. In some plants if you take an idea from somebody else, they will not accept it—will say—"It's not a good idea, you have to create one of your own." Even if it is a good idea, it's taken apart and the electrical engineer helps along in doing it. That's true. Now you may not think it, but very often that very action endangers life. I have seen it a great many times.

I wish the foremen of your workmen could hear the papers that have been read today, could hear them and become conscious of the unsafe practices they are guilty of, and from which fatalities may result. When you go back to your work, say—"I'm going to stand on my feet. I'm going to penalize"—don't use the word discharge—penalize your men for doing an unsafe thing where life can be lost. An electrical engineer can do that through the general superintendent, but if you have a general superintendent who does not stand back of your electrical engineers, then you can read all the papers in the world and they won't amount to a picayune. The greatest trouble with safety today is that men are not taking the proper interest in it. These are not idle words, they are true and they mean life. There are a great many alibi men who hold high positions and draw good salaries that say—"Oh, I can't bother with that", think they know all about it and don't need to interest themselves in the subject of safety. There is where your success with the code mentioned by the West Penn Power man becomes effective.

I want to congratulate that young man who used "personnel", but do wish he would use some other word.

**C. L. Henderson:** Mr. Chairman and gentlemen, while Mr. Hamilton has discussed many of the ideas I intended to talk about, there is one point which has been only touched upon and one which I think is of prime importance, that is, education.

As Mr. Hopper of the Duquesne Light Company stated, I think the Iron and Steel Industry is probably facing now the problem we had several years ago. When our system was small and switching equipment was comparatively simple, the operator was not required to know as much as he is today. As the system grew and service conditions became more exacting, more accurate and reliable protective devices became necessary. Station switching layouts had to be more flexible to meet the exacting requirements and consequently, the operation of substations became more complicated. The operator was required to learn and remember more in the proper operation of the new equipment and his reasoning and thinking power had to be developed to meet the new requirements. A strict operating code had to be set up that would cover various operating conditions, be easily understood and above all be strictly enforced. We found that it was not sufficient to merely write rules and let the men read them as they saw fit. In order that rules are

thoroughly understood they must be freely discussed and the "Why" and "wherefores" of them explained. We found that the most effective way of getting our operating code and maintenance problems across to the men in the field was to hold regular educational meetings which pertained largely to such questions.

For the past three years such meetings have been held throughout the system in the Operating Department once each month beginning in October and ending in May. The foreman in most cases conducts the meeting or classes, which are divided into groups, at various locations over the system, each group being limited to fifteen in number. A list of five questions is made up by certain key men in the Operating Department and sent out to the field men on the first of each month. This list usually contains two operating, two maintenance and one technical problem. Three weeks are allowed for the men to prepare their answers which must be written and presented at the class or group meeting at which time the various members are called upon to read and explain their answer. If certain members do not agree upon the answer, a general discussion is entered into and the correct answer is given and explained by the group leader. We find there are many rules in the operating code upon which questions can be asked. The official answers to each month's questions are made up by certain key men of the Operating Department and it is in these answers that we can drive home the point pertaining to the operating code and maintenance standards so effectively. The fact that a man is required to frame in his own words the answer to a question, write out the answer and discuss or write about it, makes him remember the particular rule much better than if he had simply read over the particular rule when he received his copy and then filed it away and perhaps forgotten it. With this system the code must be read and an answer framed as they understand it. We find the men take a great pride in the manner in which they prepare their answers, as they realize they will be called upon to give their answers before the group and naturally want them to be as nearly correct as possible. After the group meeting has been held, official answers to the questions are sent to each member of the group and sub-station and filed for future reference. A set of minutes covering the discussions of each meeting is prepared for purpose of having a record of any points that came in for detailed discussions, suggestions, or criticisms. All men have shown a keen interest in the classes, and frequently offer valuable suggestions regarding operating and maintenance practices and safety.

Another point that I wish to lay particular stress upon, is to let your men know that the operating code must be lived up to in detail. We find that when operating errors do occur they are invariably caused by someone trying to take a short cut and not performing all the necessary checks that should have been made to cover the switching set up or condition.

**G. R. Carroll:** Mr. Chairman and members of the Association, I didn't come here prepared to make any discussion on this subject, but I would like to say that I believe Mr. Hunter and his committee have a real job to standardize all the different rules and the different ways of doing things that have been brought out here this afternoon.

There is one thing that I don't believe has been mentioned, and that is the locking by a positive means the visible disconnecting features ahead of the oil switch. In our own plant we have tried to work out some such scheme, and we carry it out after a fashion; but it becomes quite a lengthy affair to take a circuit out of service when we insist on locking the disconnecting devices on, say, a feeder circuit with four or five sub-stations. In listening to the discussion it has occurred to me that, possibly, we are tipping over backwards a little bit in trying to do that that way; and I was just wondering if we couldn't hear more from the West Penn people or Mr. Hughes or the gentleman from the Duquesne Light as to how they feel about the necessity of locking such devices.

There is one other question that I don't believe has been discussed much—we had one discussion about grounding devices, and I believe we ought to hear more about that. That is, we have always taken the stand that cable clamps are quite a hazard when placing them on the circuits, particularly when the man is on a tower or pole with other live circuits. Consequently, we have, up to the present time, used the chain. We take quite good care of the chains. We use a small size log chain, about a quarter or three-eighths stock and hot galvanize it, we have not gotten into trouble with the use of such chains to date.

I believe that is about all I have to offer. Thank you.

**A. N. Cartwright:** We make it a practice to lock only such equipment as is liable to be operated by some person outside of the company; in other words, the pole-top switch or the entrance to a sub-station or something like that, that can be approached generally by some person who has no business whatever doing anything with that equipment. This practice, however, is not universal. There are very elaborate locking schemes. Duquesne Light, I believe, uses quite an elaborate scheme for locking, and it's quite a complete scheme of protection. We tried it on one station, and it just so happened that the only place that one key would open two locks caused an interruption and a bad one. We thought it was a foolproof setup, but, when the application was tried out over a period of time, we abandoned the scheme. We now have no locking scheme of this type, but it does not follow that the scheme is to be condemned because we have seen fit to discontinue it. On the West Penn System we have the disconnect switches open, the oil switches blocked, tags and short-circuiting—that's the system we use. We find it quite effective.

**D. C. Hopper:** We have gone quite extensively to locks, especially in the automatic sub-stations on our system. I don't know if I can give you all the details, but, briefly, the system is as follows:

Before any disconnecting switches can be operated—most of them are gang operated disconnects—oil switches must be operated and the key from opening the oil switch must be inserted in the disconnect switch lock in order to unlock and to open the disconnecting switch. I think perhaps the locking feature is more protection to the station attendants than it is to the man working on the line.

For instance, we have a power plant of some two or three hundred circuit breakers, maybe, all in a row, and a man operates an oil circuit breaker and proceeds to open a disconnecting switch on another line. With the unlocking system he couldn't take the key and operate the disconnecting switch on another line. A few accidents of that nature have led us rather extensively into locking.

As to our automatic sub-stations, that is, stations with no attendants, the circuit breakers are automatically closing, the operator of them is, you might say, a traveling man. He travels around from station to station. When he leaves a station, he leaves the lock in such a condition a man can't operate the switch until he has closed his disconnecting switches and taken his keys from the various disconnecting switches back to his oil switch and finally closed his oil switch, which is quite a combination to go through. It does slow up somewhat your procedure in getting lines out of service and back into service, but we think the safety feature is worth the slowing up that we get. I think really it's more protection to the man operating the station to make sure that he performs the correct operations than it is to the man out on the line.

**A. N. Cartwright:** I might add that we use mechanical interlocks in connection with the disconnection of oil circuit breakers; that is, the breaker must be opened before it is mechanically possible to remove a barrier or a cover from disconnect switches or to operate the handle of a gang operated disconnect switches.

**C. E. Sankey:** Mr. Chairman, regarding what was said by the gentleman from Jones and Laughlin in regard to the lock for switches. We have one or two plants where every electrician has a lock, not because he may be working on the high tension switch but we require him, when he goes up on a crane for instance, to lock the switch. There may be riggers up there, the craneman may be down below and not know the electrician is up; therefore, we make him lock out the switch and not take any chances. He carries the lock on his belt and considers it one of the tools that he has to work with.

One of the plants uses the tags—Open and Shut —and hangs them on. If we find that tag isn't on—penalization follows. Make the men realize that you mean it. Don't think of production or operation with lives at stake. The safety of the man should be the first consideration, therefore, we consider the lock is best. If I had my way, I'd have locks on all switches in every plant, then there wouldn't be so many killed.

**A. N. Cartwright:** There has been one point of difference noticeable in the discussion and that is in relation to chains or clamps and proper cable. There are on the market splendid clamps made primarily for the use of grounding lines. They are adequate; they are safe; they are easily applied. Chain is not good. It is to be recommended against very distinctly. A suggestion was made to reinforce a chain by putting some strand through the links. That will help some, but the point of contact of the chain with the wire is a high resistance point and it will burn down at that point. If your lines are properly designed and you require 500,000 or 4/0 or something considerably smaller to carry the current that goes over, (it's not voltage that burns these grounds down; it's amperes,) and you notably have heavy conductors. Therefore, I would say, especially in your business, chains should be taboo. Use a proper clamp and a good heavy cable and you'll help yourself out of a lot of trouble from that source.

**E. F. Blank:** Mr. Chairman, I'd like to reply to what Mr. Sankey inferred with regard to Mr. Carroll's remarks. Our repairmen use locks when working on electrical equipment. The man locks the switch before he goes to work; and, if there are a half dozen gangs, each puts its lock on. What Mr. Carroll referred to was high tension work, which is done, of course, only by competent electricians, he questions whether the rule which we are enforcing at the present time perhaps is practical because of the fact that great distances have to be travelled in order for the man who has charge of the work to put on the locks.

**J. Farrington:** I have very little to offer in addition to what has already been said, with the exception that we are firm believers in education in safety, even if we do lean backwards a little. At our safety meetings, which are held once a week, we take up the subject of taking a certain line out of circuit. We tell the men we are going to do that and then we ask each man who is on either end of the line to follow his instructions. We then check with him to see if he has been properly informed.

We believe in a single tag to each man, as well as a lock to each man; and, as orders are given, the sub-station man puts his orders down in his log book. The lineman on the other end puts those instructions on the back of his own tag, and no one can remove that tag or that lock except that individual man. And in that way, so far we have avoided any accident; although, as one gentleman stated, we have had to hunt some two hours to find the man who had gone away and left the lock on, we would not allow that switch to be closed until we located that man and brought him down. Then, of course, after he unlocked and took his tag off, he was penalized.

**W. R. Hamilton:** I would like to answer Mr. Sankey on my interpretation of "Personnel" why I have selected that word. When I mention "Personnel" I am not speaking of management. No safety system will work if the management is not back of it. This thought is so fundamental that if we do not have the full backing and co-operation of our management it is better work to get in first. When I refer to "Personnel" I am referring to the operator, the electrician, the lineman—the men on the firing line—not the bosses, not myself. I am thinking of the men who are actually doing the job, not the department heads who are simply telling the men what to do.

These men must be capable of absorbing instruction. That is the first and foremost educational responsibility in any organization. You can't educate a man if he is not sufficiently developed mentally to absorb the education. We all have many men in our organizations whom we know are not capable of handling the job of their buddies. In our transition from steam to electricity we have found many steam men who are not capable of absorbing the details of electrical operation. I have found this a fact during my training of some of our customer's operators.

West Penn, in its sale of electricity to the industry, considers the utility's responsibility is to see not only that the power is always at the customer's switch, but the utility endeavors to train the customer's operators how to obtain this power when it is wanted. He assumes the responsibility of helping our customers, many of the small customers, to train their operators and electricians who handle the operation of any automatic equipment which is used to obtain power from us. Many of these industries had steam plants before they began purchasing electrical power. The men who operated these steam plants had many years of service in these companies. Many of these old operators could not absorb the operation of electrical equipment. The organization often was under a mechanically trained foreman who often did not visualize the electrical problems, so our task was made harder because we did not have men whom we could teach. These experiences are my reasons for emphasizing "capable personnel". During these days when we have a wealth of material available, we should have little trouble about getting capable personnel.

We have a big task, as Mr. Hopper brought out, in the training of men who operate non-attendant stations. Certain linemen must be trained until they are as familiar with these stations as the operator is with his attendant stations. This is one difficult task as these linemen generally have to learn operating fundamentals before they will grasp the routine switching procedure.

# DISCUSSION

# Fuel Economy Under Curtailed Operating Conditions*

By H. DOBRIN,
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Presented before Combustion Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 22, 1932.

DISCUSSION PRESENTED BY

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**A. L. Hollinger,** Engineer, Surface Combustion Corp., Toledo, Ohio.
**M. J. Conway,** Fuel Engineer, Lukens Steel Company, Coatesville, Pa.
**H. Dobrin,** Consulting Fuel Engineer, Pittsburgh, Pa.
**F. E. Grenley,** Fuel Engineer, Wheeling Steel Corp., Steubenville, Ohio.

**A. G. Witting:** In his paper about improved fuel practice in the last couple of years, Mr. Dobrin brings out that the considerable fuel savings which have been accomplished in the face of very adverse operating conditions are principally due to a regulation of the air supply.

I am sure all will unhesitatingly indorse the principles for such a regulation laid down by Mr. Dobrin in his paper. The object of my participation in the discussion is only to emphasize them.

The furnace operator has always had complete control over the fuel supply but has until lately been at the mercy of the individual and changing vagaries of the draft conditions of the furnace in his attempt to regulate combustion. The advancement that has been made in fuel economy has been entirely won through combatting this deficiency.

In the mechanization of combustion, sight must not be lost of the fundamental importance of a proper port design for an open hearth furnace, which has to be studied individually for each furnace. Similarly, the proper construction of burners, where liquid fuel or coke oven and natural gas are used, is of deciding importance, if the most suitable flame condition is to be obtained.

But it is not sufficient to obtain the proper flame condition; it must also be **maintained.** It is in this respect that the mechanical means have proven themselves invaluable.

A forced draft fan, the capacity of which can quickly and easily be regulated, eliminates the uncertainty of the ratio of air to fuel. If the heating conditions permits this ratio to be held constant over the full range of operations, an automatic control will prove to be of great help. Its value is however questionable when variations in the ratio are desirable in the operation of the furnace or where internal gasification at times tends to upset the ratio.

It is not sufficient to control the combustion proper, i. e. to give the fuel the exact amount of air needed; any addition of air above the necessary amount is detrimental in several respects. Also, all the fuel supplied to the furnace must be usefully employed. A neutral pressure must at all times be maintained in the furnace room. If the stack draft is too strong, cold air will leak in; if it is insuffic-

* Paper appeared in the September issue of the Iron and Steel Engineer.

ient, combustible gas will leak out. It is necesary to maintain the proper condition by means of an induced draft fan, the capacity of which is regulated to carry away the exact amount of waste gases produced maintaining a balanced draft in the furnace. An automatic control capable of such regulation with immediate response to any changed condition in the furnace is essential and will perhaps do more to reduce fuel consumption than anything else.

The utilization of fuel is however not completed in the furnace itself. The heat carried away by the waste gases must be recovered to the greatest extent possible, whether by preheating the air used for combustion or in waste heat boilers. In either case it is important to reduce any loss of this heat as far as reasonably possible. These losses are due to radiation from the walls of checkers, recuperator chambers and flues and to infiltration of cold air through these walls. Aside from other gains, sufficient heat otherwise lost is recovered in a useful way to pay for the expense if these walls are made leak proof and strongly insulated.

Whether the full step toward automatic control is taken or not, the results in fuel savings will at all times depend on the intelligent handling by the operator of the mechanical equipment at his disposition. He would not be their master unless he can tell just how they function. He must have instruments that record the flow of gases and air, pyrometers that record the temperatures, draft and pressure recording gages, which instruments also permits a complete checkup by the management of the actions of the operator.

While discussing the paper of Mr. Dobrin, there is a statement, not connected with the question of fuel economy, but otherwise of interest that may need some comments. We are striving toward a standardization of fuel values. It is therefore the only correct way to express fuel consumption in B.T.U. as Mr. Dobrin very properly does. But the units employed by him need some revision. Seven gallons of oil equal one million B.T.U., but for tar 6.25 gallons is more correct. As to producer gas the commonly used standard value for coal is 13,500 B.T.U., which very nearly corresponds to the actual value, if we consider the gross heat value obtained in a calorimeter as actual. The conversion losses will in my opinion not exceed 8% i. e. the latent and sensible heat carried to the furnace system by the producer gases will for every pound of such coal gasified amount to about 12,400 B. T. U. (the net heat value would be about 12,200 B.T.U). Consequently placing the producer gas on the same basis as tar, oil and coke oven gas, 80 to 82 lbs. of coal in the producer represents one million B.T.U.

**E. A. Brown, Jr.:** Financially speaking, of course everybody abhors the depression, but from the standpoint of combustion progress, the combustion engineer has lots of things to be thankful for, I believe. In years like 1929 everybody is so busy on production that lots of combustion propositions are overlooked, lost in the shuffle or not carried on; but since the depression period, I'm sure lots and lots have had the same experience that Mr. Dobrin has brought out in the economic consumption of fuel, and it has been rather easy for the combustion engineer in a way. He has merely had to go to his files and bring out work that was done in the past ten years; and, with a redressing, re-submit it and have it put into effect at the present time. Things that would not be listened to at a previous time have been readily taken up, and the depression has offered the opportunity for a lot of the ideas that the combustion engineers have accumulated to be put into effect.

Every combustion engineer, I think, has one line of approach—one particular line among others—and that is to hang up in front of operators or management good figures that have actually been made and then say "You did it before, now do it again." At the present time we are hanging up a lot of excellent figures to shoot at and I think we don't want to dwell on the depression too much. What we want to think of more now is that, when we get out of the depression, there will have been a lot of ideals set up that are going to carry on with increased production, and that it is much easier to put certain things across now than it was when we had good business before. We don't want to forget what we are learning now, and meanwhile find it an excellent time to make combustion hay even though the business sun fails to shine.

**F. Burdette:** I do not have much to add, Mr. Chairman. My remarks would be in line with Mr. Brown's, that Mr. Dobrin's paper was rather a pat on the back for the combustion engineer. The economies cited are in line with the drastic economies made in every department in the steel mill. The real measure of the effectiveness of combustion engineering will show up on increasing production. We will have to see whether the low fuel figures hold when production, not cost, is the primary thought in mind.

**F. E. Grenley:** I have little to say except that the figures presented are very good.

I would mention that when an open hearth plant operates at 60% instead of 100%, fuel economy should improve due to less furnace delays. I would like to ask Mr. Dobrin if he used net B.T.U. or gross B.T.U.?

**H. Dobrin:** Net.

**F. E. Grenley:** Gross or Net tons?

**H. Dobrin:** Gross.

**F. E. Grenley:** And ingot heating, do you use finished weights?

**H. Dobrin:** Finished product.

**C. L. Joly:** It has been our experience that heating controlled by a properly organized and trained combustion department is attended by fuel economies under high production which can hardly be expected without any control or properly organized combustion department.

You will find that with the reduced production and small number of furnaces in operation today that the Superintendents and such few Combustion men as you have in the plants are more than able to maintain almost proper operating conditions in your furnaces. However, when you have a large number of furnaces in operation, it is humanly impossible for the men to maintain these conditions in furnaces which, in seventy-five percent of the cases are not properly designed.

The installation of fool proof Combustion Control equipment, which the manufacturer has taught the Combustion Engineers in the plants to use properly, will pay for itself, in the majority of cases,

in from four months to one year. This is a very handsome investment.

Unless you have a proper Combustion Department and you have the co-operation of the manufacturer in educating your men to the use of whatever Control equipment you may install, do not buy any equipment of this sort as it will be a dead loss.

I believe that this answers Mr. Burdette's question.

**A. L. Hollinger:** The fact that conditions such as Mr. Dobrin outlines exist today is certainly a tribute to the modern combustion engineer. The degree to which savings like this can be made is a function of the importance which management places on the duties of the combustion engineer. It is surprising, only, that these improvements as covered by Mr. Dobrin are not being made in many plants today.

One thing that we notice frequently is the question which arises as to the kind of fuel and type of firing system for a particular heating operation. A mill superintendent or operator is inclined to say "Well, we may use Coke Oven Gas, we may use Blast Furnace Gas, we may use Oil, or we may use Producer Gas, and we want an arrangement which will handle any one of these fuels at will". It is the easy thing to say and is many times merely a procrastination of an investigation on which to base a sound fuel policy. The combustion engineer knows instinctively that one design and one system of firing will not handle these different fuels each to the best advantage. Many times, however, he does not take a strong enough stand on this question and compromises on a firing arrangement which reflects in high fuel costs.

There are two alternatives in a case of this kind: either establish what fuel is to be used and design the firing equipment for that fuel; or, face the fact that this furnace must be designed with several firing systems so that each fuel that may possibly be used can be used efficiently.

During the paper on the care of instruments, I recalled a striking experience that we had a short while ago in a plant where no individual was specifically assigned to the duties of combustion engineer. A furnace was installed in this plant about a year and a half ago and was equipped with the most modern and efficient firing system available. Fuel rates were remarkably low. However, after something over a year of operation it was casually discovered that the fuel consumption had increased nearly 50%. We were asked to inspect this job and found that the consumption could be brought back to its original point by a cleaning operation on the equipment that required about thirty minutes. As a matter of fact literally hundreds of dollars had been spent that would have been saved had somebody been given the responsibility of periodically inspecting high grade equipment to see that it was in proper operating condition.

**M. J. Conway:** A study of the statistics presented by H. Dobrin in his paper is to say, in the least, interesting and according to the various data throughout the paper, the results were obtained by use of one or more of the following:

Pressure fans.
Checker chamber temperature indicators.
Changing uptakes.
Balancing drafts.
Reducing excessive drafts.
Improving slopes of furnace ports.
Increase in tons per furnace hour.
Upkeep of furnace equipment.
Checking furnace atmosphere.
Study of gas pressures and heating cycles.
Decreasing standby time of empty, hot furnaces.
Utilizing functions of combustion and metallurgical departments.
Decreasing air infiltration and stopping up cracks and crevices.
Improving furnace lines.
Maintaining balanced draft by manipulation of dampness.
Decreasing excess oxygen.
Improving control apparatus performance.
Flue gas analysis.
Improving operating mechanism of furnace dampers.
Greater use of insulation.

These may be further sub-divided into

**Management**

Utilizing functions of combustion and metallurgical departments.
Greater use of insulation.

**Supervision**

Changing uptakes.
Improving slopes of furnace ports.
Increased tons per furnace hour.
Checking furnace atmosphere.
Decreasing air infiltration.
Improving operating mechanism of furnace dampers.

**Operation**

Reducing excessive drafts.
Upkeep of furnace equipment.
Decreasing standby time of hot, empty furnaces.
Maintaining balanced draft by manipulation of dampers.
Decreasing excess oxygen.

**Control**

Pressure fans.
Checker temperature indicators.
Balancing drafts.
Study of gas pressure and heating cycles.
Better control apparatus performance.
Flue gas analysis.

These may be further classified as

**Management—Plant**

Pressure fans.
Checker temperature indicators.
Utilizing functions of combustion and metallurgical departments.
Greater use of insulation.
Balancing drafts.
Study of gas pressure and heating cycles.
Better control apparatus performance.
Flue gas analysis.

**Management—Departmental**

Maintaining balanced draft by manipulation of dampers.
Decreasing excess oxygen.
Reducing excessive drafts.
Upkeep of furnace equipment.
Decreasing standby time of hot, empty furnaces.
Changing uptakes.
Improving slopes of furnace ports.

Increasing tons per furnace hour.

Checking furnace atmosphere.

Decreasing air infiltration.

Improving operating mechanism of furnace dampers.

The results cited by H. Dobrin are within the reach of all plants, if co-operation and responsibility are properly shared by those in charge. The brick masons department must accept an order to stop up cracks and crevices with the same grace that the heat treating department does when ordered to increase the annealing and normalizing temperature 25 degrees.

After correct and intensive training, the biggest job the combustion engineer has to do is that of selling the truths he has discovered to the departments who are to benefit. Management is prone to shoulder the efficiency of operation on those engineers who "potter" with the operation.

The true worth of the combustion engineer is in his research and fact finding efforts and in his ability to present these facts in a clear and expeditious manner to suit the case under consideration.

**H. Dobrin:** Well, Mr. Chairman and gentlemen, of course there is the question brought up by Mr. Witting, of the Illinois Steel Company, who is not present. Quite a good deal can be said regarding what is the proper charge when you use producer gas so as to place the user of producer gas on a par with the user of coke gas or natural gas, who has only to turn a gas valve. While in one case you are having a definitely high concentrated fuel without any dust, dirt or deposit of soot, in the other case you have all the inefficiencies that are inherent in the use of a dirty producer gas. The man who uses free, clean coke oven gas or clean natural gas cannot fairly be compared with the man who uses producer gas in what he uses in b.t.u.'s. If you are going to charge him for the same b.t.u.'s that were in the coal which the other man had in the concentrated fuel, I don't see any fairness or wisdom in that.

Mr. Witting says the difference will be only 8%. That would be okeh if one ran a laboratory test and said the theoretical losses are only 8%. Now we all know that there is no such thing. We all know that the moment you want to get down and make producer gas on a laboratory basis one thing is surely going to happen—you're going to quit making producer gas. You're not going to be able to make producer gas which is going to be useful to the man who uses it on that basis. When people say they want only 4% $CO_2$ in producer gas, I tell them they might just as well go into the laboratory, because you won't be able to make 4% $CO_2$ producer gas and make it in quantities so that you won't have to spend another half a million dollars for additional equipment. How is anyone going to get six or seven thousand pounds out of a producer unit if you're going to be too technical and get a loss of only 8%?

The legitimate charge to be made in all fairness to the user of producer gas as against the user of coke oven gas has been found to be about 76%. In other words, we've got to acknowledge that there is a loss of 24%. This is my belief and it is not only my own belief but the belief of other men who are my associates in this work and who have devoted years and years of study to the standardization of the various values of fuels used in order to be of practical benefit to the man in the mill. There may be any kind of theoretical loss, but there is no use in telling a man he's got a million b.t.u.'s if he doesn't have any million b.t.u's in potential heat and only gets 76% of it.

Therefore, converted into producer gas, you must say 95 pounds of coal equals 1,000,000 b.t.u.'s, which is 10,500 b.t.u.'s per lb.

This Society has endeavored to cover this question of standardization of fuel values, and the management of this Society has tried to gather quite a number of representative facts and figures from organizations who have long paid a great deal of attention to this work. Now we take a firm like the American Rolling Mill Company, who have been more than willing to co-operate with this Society in arriving at standarization; and, in view of the attitude of their management, I am not divulging any secrets if I tell you that in the American Rolling Mills 10,500 b.t.u.'s is the standard used per lb. of coal if it is to be made into producer gas. For every lb. of coal that is thrown into the producer unit, the furnace user is charged with 10,500 b.t.u.'s, and that has been found an equitable and just figure. This very company has used different kinds of fuel—producer gas and natural gas and by-product gas and oil—in its different plants, and has made actual comparisons.

Now this is as far as I thought it would be well to go into discussion in answering Mr. Witting. The figures that I have used are practical figures. Mr. Witting's suggestion represents a purely hypothetical figure which I know, from my own experience and the experience of many others, is never obtained in actual operating practice.

Furthermore, the paper today really is a sequel to the paper which I had the honor to read before this Society a year ago in Cleveland. There I explained in considerable detail the individual things that the combustion department has to do in maintaining a burner, in watching for leaks, in watching for the breakdown of the burner. Now, this year I didn't think it was going to be necessary to repeat what I said last year.

# DISCUSSION

# Roll Neck Lubricants and Lubrication*

By W. D. HODSON,
President, The Hodson Corporation,
Chicago, Ill.

Presented before the Lubrication Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 23, 1932.

DISCUSSION PRESENTED BY

**W. H. Mandy,** Lubrication Engineer, Tennessee Coal, Iron and R. R. Company, Birmingham, Ala.

**J. H. Eyman,** General Master Mechanic, American Steel & Wire Company, Donora, Pa.

**L. P. Tyler,** Technical Mgr., Vacuum Oil Company, Pittsburgh, Pa.

**S. M. Weckstein,** Engineer, Timken Roller Bearing Company, Canton, Ohio.

**F. P. Dahlstrom,** Engineering Dept., Morgan Construction Company, Worcester, Mass.

**W. H. Mandy:** I think Mr. Hodson has done a wonderful work in bringing to our attention some of the things, regarding Automatic Pressure Lubrication, that we know so little about.

Automatic Pressure Lubrication for roll necks on all types of mills is rapidly being recognized as an asset to the mill and I believe the value of this type of lubrication will be more fully appreciated when we are more familiar with the actual savings we can expect to obtain. There seems to be a lack of information regarding the actual cost of roll neck bearings in most all mills. In many cases we are able to determine the cost of bearing brass and babbitt charged to a mill over a certain period of time but how many of us know just what we are saving when we double the life of a bearing? When we double the life of a bearing we certainly must be saving power but how much is this power saving? Unless we can answer these questions we do not really know the value of Automatic Pressure Lubrication.

In the development and perfection of equipment for automatically applying lubricant to roll necks I have noticed a considerable change in the amount of lubricant applied at each interval and in the frequency of application. A very small amount of grease applied at frequent intervals reduces the waste of lubricant and maintains a better film on the roll neck.

**J. H. Eyman:** I feel very grateful to be present here today and for the opportunity of listening to the wonderful paper read by Mr. Hodson on Lubrication and Lubricants for Roll Necks. I am sure that I am going to take back a lot of good points from his paper.

One of the highlights of his paper dwelt on someone being held responsible for supervision of proper lubrication and lubricants, whether it be the master mechanic or the lubrication engineer. I think we can take a lot of good thought out of that paper, and I think we will all agree that the Association's taking up the question of lubrication and lubricants is just another step in the path of progress. I believe that we also will have to agree that the proper supervision of proper lubrication, properly applied, is a real foundation of strict economy in power transmission and in production cost.

**L. P. Tyler:** I enjoyed very much Mr. Hodson's paper, because one of the things he particularly brought out was the fact that the endeavor to improve the condition of lubrication, particularly roll neck lubrication, seems to be working from the bottom up. In the opportunities that I have had to visit many steel mills throughout the United States, it has always been recognized that the question of roll neck lubrication was one of the most serious problems which they had, and one which was subject to the greatest degree of improvement; and in many of those plants we find the master mechanic and the lubrication engineers developing their own particular systems and working out plans to apply the lubricant automatically to the bearings. As a result of that, there are now on the market a number of standardized, mechanically operated automatic systems, which have been doing a very wonderful job from the standpoints of assisting in the reduction of power and increasing the life of the bearings, as well as reducing the cost of lubrication. It is quite obvious to anybody who has looked at a mill bearing of the old design, where hard grease was applied on the neck someplace and if the rats didn't carry it away a little bit finally worked its way into the bearing area, that any reasonably practical method of application would offer a very substantial improvement; and that has been the case.

It is true that there are not a great deal of facts and figures in connection with exactly what has been saved—I mean sufficient data so that a man can absolutely say he's saved a certain percentage. But almost anybody who has talked with mill managers will agree that the differential in the life of the bearings now as against what it was is very great; and that it is evident, from power tests that have been run as well as from measured lubrication costs, that very substantial savings in the cost of mill operation have been effected. Even on bearings where no mechanical system is applied, where they are using hard grease and where, of course, the water and scale tend to wash away the lubricant, by taking those bearings and putting a nice

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

wide, deep chamfer at the entrance of the lubricant and using perhaps a grease of a better consistency and a higher quality, we have found that the tonnage on certain bearings which have had those simple changes made in them has increased two to three times.

This may be taken as an indication of the fact that the problem is very largely one of improved application of the lubricant—in other words, a matter of getting the lubricant to the point where it is necessary to separate the contact surfaces, or what might otherwise be called the pressure area.

In the new systems, as you all know, it is a matter of applying the lubricant at a point where it is possible for the roll neck to carry it in to the pressure area and thus produce the film which is necessary. As an illustration of that, we all know that in lubricating turbine bearings the problem of wear on the turbine bearing is something that is generally not even considered. We use oils that are very light in body as against what we are talking about in connection with roll neck lubrication, and that bearing gets lubrication due to the fact that you supply to a finely designed, well polished shaft a lubricant in suitable amount so that you will actually establish a film of sufficient thickness to ride the shaft on its bearings.

I think it is up to the large oil companies, of one of which I happen to be a representative, to do more work for the benefit of the steel industry in connection with testing machinery and the working out of lubricant types for different types of bearings. Our company has this matter under consideration, and is working out in their laboratory a machine with measuring devices so that we can run tests with pressures as high as five or six thousand pounds per square inch.

**S. M. Weckstein:** I made a few notes on Mr. Hodson's paper, especially with reference to lubrication of the roller bearings and the fact that the various roller bearing manufacturers did not have any data to give Mr. Hodson when he asked for it. I think the Lubrication Committee of the Association can do more towards helping us get that information than any individual.

Every time a concern adopts our bearings, we try to get them to keep a record of the tonnage rolled on the bearings as well as the cost of the lubrication; and in some cases we have had a very fine response but in other cases we have had no cooperation at all. I think the reason for it is the fact that there is not a standardized form in the various mills on which to keep these records.

In the mills of the Timken Steel & Tube Company, we were very anxious to work out something, because we were constantly approached for this information; and the system that we set up is far from being perfect but it is giving very fine results. Every bearing in our mills—and, for that matter, every bearing that is shipped to any mill installation—carries a serial number, and we recommend that the mill operators when they receive these bearings also add whatever identification number they want. We also number the rolls and we number the chocks in which the bearings are installed. The recorders on the mills are given definite instructions that one of the most important points on the record sheet is this data—the number of the roll, the number of the chocks, and the number of the bearings that are being used. From that we have been able to get a definite record of tonnage, number of hours' operation, and revolutions on every bearing, in the mills of the Timken Steel and Tube Company. We know that other companies are keeping such records; and we hope that, as soon as they get them developed to a point where they have something interesting to offer, they will turn these records over to the Association and to us so that we can use them.

There was one other point that Mr. Hodson brought up in his discussion of lubrication and the method of applying the lubricant. Mr. Hodson mentioned that Mr. Brunner of the SKF Company at one time wrote him that sometimes it is much better to run bearings with very little lubricant. That, I think, is a point open to discussion, and I think it can best be handled by considering every problem individually. I don't think you can set down any rule as to what your lubrication requirements are.

Now, as to the method of applying the lubricant we have found that in order to keep water and foreign material out we have to carry the boxes chock-full of grease. At first we thought we had them chock-full, but found they were two-thirds full of air and one-third of grease; and we weren't getting the right lubrication. It is absolutely necessary to have bearing boxes properly vented whether using grease or oil, to obtain proper lubrication.

The reason we have been recommending on the large mill bearings, grease lubricated, that the grease be applied at the bottom is so that a proper vent can be located at the top where it belongs. In the case of circulating oil systems, we put the oil in the top rather than the bottom; but here we had to work out special means of taking the oil away fast enough to be sure the bearing was being properly lubricated.

As to the type of lubricant to be used, that is one of these things where necessity has been the mother of invention. No one gave a hang as to what should be used until people got into trouble. Now all of the lubricating companies have been co-operating very, very closely with our lubrication engineers, and we believe we have developed lubricants suitable for the various types of applications which are d ng a very, very fine job.

**F. P. Dahlstrom:** I wish at this time to mention the Morgoil bearing which is a flood lubricated, sleeve type, roll neck bearing. When a bearing is properly lubricated we ought not to worry about wear, and we do not, for in the Morgoil bearing the load carrying surfaces are separated by a film of oil of definite thickness which can be calculated. We have read of experiments being made in which sized emery was fed in with the oil while the bearing was running in order to check the calculations. After this, clean oil was again turned on and the machine stopped, and upon examination no scores were found. The minimum oil film thickness in Morgoil bearings is 1/1000" which is ample to protect both journal and bearing.

In appearance the Morgoil bearing appears to be a substantial steel block or housing having inlet and drain connections. By means of flexible hose and detachable connecting fittings, the bearing is readily connected to existing oil circulating systems. The

housing at the working side of the mill is provided with a complete and simple double-acting thrust bearing and the journal in the opposite end is free to float in its bearing. Lugs and fittings are provided so that the roller can make all endwise adjustments of the roll from the working side of the mill, and the design is such that no useless thrust loads need be carried. Bescause of this, no thrust wear occurs and the only adjustments made, both radial and thrust, are due to pass wear only.

Each bearing may be removed from the roll as a complete unit. This is readily accomplished by first unscrewing a nut and removing the split ring after which a wheel puller is applied. The puller is tapped with a hammer and the bearing is then free from the roll neck. The roll neck is tapered which permits this easy removal of the bearing, and the design of the taper gauges is such that the workman can easily make roll necks having accurate taper. We find that the units which we make according to the same system of gauges are actually easily interchangeable and that they always fit the neck. The roll neck is not used as the bearing. The outer part of the sleeve contained in the housing is carefully made for this purpose which results in two important advantages. First, the bearing proper is not exposed to mill scale at any time, and, second, the bearing cannot be damaged when being assembled on or removed from the roll neck.

Another important feature of the bearing is that no sacrifice of neck strength was made in the design. Rolls made by our company, as well as those by others, have necks approximately two-thirds the body diameter. The necks of the rolls for the Morgoil bearing where they join the body of the roll are larger than our previous standards.

As would be expected, these bearings have withstood severe punishment both in our laboratory and in the mill. As a result, necks and rolls have broken but the bearings do not fail. More than ever before, it is now an important problem of the roll manufacturer to produce a roll having the surface strength of a chilled cast iron roll together with the neck strength of an alloy iron (or grain) roll.

It may be interesting to review the coefficients of friction for various type bearings.

Air itself is a lubricant, and in Worcester a certain manufacturer of grinding machinery has been experimenting with air lubricated bearings for some time. As far back as 1897 Professor Kingsbury mentions his experiments with an air lubricated bearing 6" in diameter with which he obtained as a minimum the extremely low coefficient of friction of .00075.

The coefficient of friction of roller bearings is usually taken as .002. I believe that at higher speeds the friction coefficient is somewhat higher due to lubricant churning, sealing devices, etc.

The minimum coefficient of friction of Morgoil bearings may also be taken as .002. At higher speeds the friction coefficient (and also the carrying capacity) increases. The coefficient of friction may be controlled by the design, and with high speeds and light loads a fair value would be .01.

In both the roller type and Morgoil bearing the power loss due to neck friction is therefore negligible.

Considering the recent phenolic laminated type of bearings, we note that Mr. Shirk and Mr. Richardson report very low coefficients of friction in their laboratory tests. In some cases a value as low as .003 has been obtained. Polished steel journals were used, which is an important factor. It is still a question as to how low the value will be with present mill conditions. We recently made careful measurements in a light duty, high speed mill and found the coefficient of friction to be .03.

Coming now to the usual type of plain bearing, the coefficient of friction depends upon the amount and consistency of the roll neck grease used, and also upon the cooling effect of the water on the neck. With necks practically free from grease, but flooded with water, we have found the coefficient of friction to be as high as .30. The usual values range from .06 to .20 and the lowest we have been able to obtain in a test is .05. For basis of comparison the coefficient of friction is frequently taken in this country as .07. Mr. Bloomquist of the SKF Company informs me that in Europe the coefficient has been considered to be from .05 to .10.

We note that Mr. Hodson suggests that extreme pressure lubricants should be more suitable for the sleeve type bearing which we have developed, rather than the usual type of circulating system oil. We do not believe this to be so; in fact the viscosity of the oil is the only factor which enters into our bearing calculations.

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# DISCUSSION
# Lubrication of Gear Teeth

By F. P. DAHLSTROM
Engineering Dept., Morgan Construction Co., Worcester, Mass.

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Presented before the Lubrication Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 23, 1932.

There is a field for extreme pressure lubricants and this naturally leads to the subject of gears. As we are today talking lubrication it may be of interest to speak of gear teeth failures which are seen every day and to discuss the influence of lubricants in connection with these failures.

Pitting of tooth surfaces has often been seen and in the case of reduction units the pitting occurs on the smaller gear, but unless the loads are very severe it is not as often seen on the larger gear. In the case of mill pinions or other such drives where both gears are the same diameter, an equal amount of pitting will be observed on both gears, and in both of the above cases if the teeth are helical (or herringbone) most of the pitting will occur below

FIG. 3

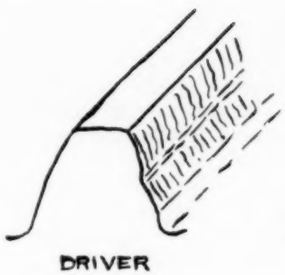


FIG. 1

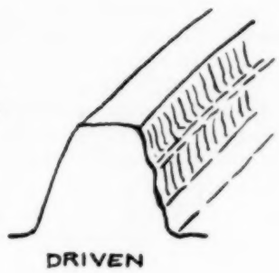


FIG. 2

the pitch line. If the gears have straight teeth most of the pitting will occur at the pitch line.

Pitting results when the compressive fatigue limit of a material is exceeded. The character of the lubricant has only a slight influence in pitting of the usual rolling mill gear. It will be observed that pits are located in an otherwise polished surface, and that there is usually an almost total absence of scores, both of which indicate that the lubricant is doing its work.

Knowing the size of the gear and the applied load, the width of the line of contact between a pair of mating teeth can now be calculated. We can then easily determine the compressive stress at this contact point. The steel usually used in rolling mill gears will carry up to approximately 100,000 lbs. per sq. in. at this contact area before pitting will occur, and the hardened gears used in automobile transmissions can carry contact loads up to 250,000 lbs. per sq. in.

We are pleased to say that, after reading Mr. Coffin's paper "Some Operating Experiences on Continuous Lubricating Systems for Main Roll Drives" in the current (June) number of the "Iron and Steel Engineer", we are in entire agreement with his conclusions regarding the suitability of ordinary mineral oil as a lubricant for rolling mill gears.

There is, however, another condition of tooth surface sometimes seen which is caused by insufficient lubrication.

Referring to Fig. 1, no doubt all of you have seen teeth like this in which a depression or groove occurs at the pitch line together with scores above and below the pitch line. If the mating gear is examined you will find that it invariably looks like Fig. 2 where we now find a ridge at the pitch line and, of course, characteristic scores above and below the pitch line. Tooth surfaces, like Fig. 1, are always found on the driver, while surfaces as shown on Fig. 2 are always found on the driven gear.

Reference to Fig. 3 will show the reason for this. Three positions of tooth engagement A, B, and C are indicated.

Position A shows the tooth of the driver at a point where it is beginning to engage with the driven gear. Continuous rotation of the driver in the direction of the arrow will cause the teeth to mesh deeper and if the surfaces are dry the teeth in the driven gear will tend to file or rub the tooth surface of the driven gear toward the pitch line, as shown by arrow b. Similarly the driven gear by rubbing against the driver will cause the surface of the driver to flow away from the pitch line as shown by arrow a.

Position B shows the teeth fully meshed. Contact now occurs at the pitch line and the tooth surfaces are rolling against each other, the sliding action above described having ceased.

Position C shows the teeth as they are about to be dis-engaged. It will be seen that the teeth of the driver have now been rubbing the teeth of the driven gear below the pitch line but still in a direction toward the pitch line as shown by arrow b. The tooth surface of the driver has meanwhile been rubbed away from the pitch line as shown by arrow a.

Summing up the above, during engagement the tooth surfaces of the driven gear are rubbed in a direction from the tip of the teeth to the pitch line and during dis-engagement are rubbed from the bottom of the teeth toward the pitch line. The tooth surfaces of the driver, during engagement, are rubbed from the pitch line to the bottom of the tooth and during dis-engagement are rubbed from the pitch line to the top of the tooth.

With the ordinary steels used in rolling mill transmission, and in the absence of sufficient lubrication, it requires only a short time for the tooth surfaces to be deformed as shown in the Figures. It is therefore extremely important that the teeth be continuously lubricated for once the tooth outline is changed no amount of running-in will restore the correct outline, even though perfect lubrication is subsequently obtained. With insufficient lubrication then the teeth in both driver and driven gear will be scored either above or below the pitch line. In such a case look to your lubrication system at once before the characteristic groove and ridge appear. If the lubricant used is known to be continuously applied and the trouble still persists, call in the lubricant specialist and at the same time notify the manufacturer, and thus help him improve his manufactured product.

As pitting is a failure of material, there is little that can be done to a pair of installed gears. As long as there are no scores or grooves we cannot blame the lubricant or the system. In very large gears pits up to ¼" in diameter may form but due to cold working the pitting will not usually progress after say six months. Under severe conditions, however, the pits may be larger and will continue to appear but it is surprising to note how long gears have been running with this condition. We are constantly carrying on research work with gear materials and as a result pitting in important gears has been practically eliminated.

Since surface pressures are known to be so high we naturally wonder why the mineral oils used at

present in many rolling mill drives prevent metallic contact, with resultant scoring.

A lubricating film is a very strong thing and with reasonably smooth surface, pressure alone does not seem to destroy it. The answer seems to be that the resulting heat, due to combined pressure and sliding, is responsible. If we ran a steel shaft in a steel bearing we would certainly expect trouble with "galling". Is this not a welding phenomena?

Ordinary steel gears do not "gall" or weld because the pressure is not maintained at any given point for any appreciable length of time. The area of pressure is constantly changing so that the film does not have time to heat to any harmful extent.

Next consider a worm gear drive. The tooth pressures are not much greater than in ordinary gear drives but we know that a worm gear drive is more sensitive to galling or scoring so we use a heavier oil. Since the worm slides against its gear with a high velocity, and since the area of pressure travels comparatively slow across the face of the worm gear, we ought to expect more heat to develop. The heavier oils have a higher flash point, and probably this fact is important in maintaining the film when we consider the heat generated.

The Hypoid gear drive has a more severe sliding action than many worm gear drives. It was brought out chiefly for automobile rear axle drives and here the surface pressures may at times be over 250,000 lbs. per sq. in. It is no wonder that with this pressure, together with the pronounced sliding action, that ordinary lubricants fail.

Extreme pressure lubricants were developed to meet this condition. They contain various chemical compounds which act on a steel surface and prevent galling or welding. According to Mr. Mougey of the research laboratories of General Motors, sulphur seems to be an important agent. To weld steel we clean it and apply a flux before heating. A coal fire containing sulphur prevents good welds from being made. Professor Buckingham, who is an authority on gears, has aptly called the ingredients in extra pressure lubricants "anti-fluxes".

We all know that sulphur in oil makes a good compound for cutting tools. I have been told also that sulphur has helped when used in lubricants for cold drawing wire.

These are certainly examples of high pressure lubrication.

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# DISCUSSION

# Report of A. I. & S. E. E. Ladle Crane Committee—Wire Ropes*

By F. W. CRAMER
Chairman and Chief Electrical Engineer,
Republic Steel Corp., Youngstown, Ohio

Presented before Electrical Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 21, 1932.

▲

DISCUSSION PRESENTED BY

**J. F. Howe,** Wire Rope Engineer, American Steel & Wire Company, Worcester, Mass.
**A. J. Morgan,** Chief Engineer, John A. Roebling & Sons, Inc., Trenton, N. J.
**H. W. Ball,** Asst. Chief Engineer, Morgan Engineering Company, Alliance, Ohio.
**W. D. Keller,** Engineering Dept., Alliance Machine Company, Alliance, Ohio.
**C. K. Traber,** Chief Engineer, A. Leschen & Sons Rope Company, St. Louis, Mo.
**W. E. Miller,** Electrical Supt., Bethlehem Steel Company, Johnstown, Pa.
**A. W. McAuly,** Electrical Supt., Edgewater Steel Company, Oakmont, Pa.
**J. A. Voss,** Safety Director, Republic Steel Corp., Youngstown, Ohio.
**J. Farrington,** Electrical Supt., Wheeling Steel Corp., Steubenville, Ohio.

**J. F. Howe:** I am glad to be here this morning, gentlemen, and to say that I believe this paper that has just been read is one that is well worth the consideration of everybody in the iron and steel industry.

I want to emphasize the points brought out in one or two cases here, particularly the matter of equalizer sheaves. I have stood for a good many years for elimination of these small equalizer sheaves. The data presented in this paper shows that these sheaves are about one-third of the proper diameter. Now, as was brought out in this paper, those sheaves are usually located in an inaccessible place where the man inspecting the rope can't tell what the condition of the rope is; but underneath, due to the small amount of motion of those sheaves, we have a very bad condition which escapes notice. And ropes usually have to be renewed on cranes of that sort due to trouble at the equalizer sheave or the breakage that occurs there; whereas, with the use of an equalizer bar and cutting the rope into two pieces, longer crane rope life usually results.

The matter of crane design is one, of course, that the crane manufacturers, I think, are giving considerable attention to, the matter of sheaves in particular. Now soft cast iron sheaves wear very rapidly. Steel sheaves don't wear quite as rapidly. But a high grade manganese sheave, properly ground and put on a crane, is still better. There has been a change in almost all of the industries using sheaves, and they are going very largely to these very hard sheaves. Now the rope maker doesn't feel at all bad to have a hard sheave on which his rope runs, be-

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

cause the hard sheave is not as bad on the rope as a softer sheave.

In the design of these sheaves and on many of these cranes, you will find that, if you compare the groove of the sheave and the leads, unless the two things are put together in such a way that one takes care of the other,—in other words, that the flange is made with a sufficient flare so that the leads don't cause flange rubbing,—the cable will frequently wear against the flange at some point in its travel. That is either as it approaches the top of a lift or at some other point. It is very important that the leads be so arranged that, no matter where the crane is going to travel in its duty, you don't get flange rubbing. Flange rubbing is very bad on the life of the rope.

Another point that needs study, I think, is the matter of a better standardization of reeving. There are a lot of different reevings used on cranes, and many of you men have seen cranes and said, "Well now, that's a fine reeving." You see another crane and you say, "I don't think that reeving is as good." You can almost sense it by looking at a crane. Of course, the general principles of a crane reeving are well known; but, in carrying them out, sometimes the reeving is given secondary consideration instead of first consideration. It is very important that the crane reeving be such that the rope travels in the same direction without reversing itself. In some crane reevings the rope reverses itself, and that is the cause of destructive life and fatigue on crane cables. If the crane reeving is simplified so that we get a natural path for the rope and we eliminate the bad leads and flange rubbing, and also see that we don't use too many parts of rope in our reeving, the life of crane cables will be greatly prolonged.

There is an economical point in rope usage. If you go to too many parts in the rope reeving, you take a smaller rope than you would normally take. It goes around the sheaves a good many times, and a certain part of that rope travels a good many feet through your reeving. The part that travels the farthest wears out the quickest, and that is the point where the rope fails first and is usually the cause of removing the rope. I think, from the data presented on these later cranes here, that that has been largely taken care of, although I would like to have seen in some cases more data as to the number of parts of rope used on these cranes so that a check-up could be made of the loads. I know it is the tendency to overload cranes. That has occurred in some of our own plants, and I have stood fast against overloading these cranes; because, if you begin to overload the cranes, you overload the ropes, and you are cutting down your rope life, cutting down your safety practice—you're getting away from the condition that you want to maintain on a ladle crane, and that is safety with the longest possible life and general good conditions, because of the hazard that is involved.

My suggestion would be that, if you could obtain more data on the reeving of cranes and come to a better understanding of what would be the preferable reeving for cranes of certain sizes, that would be a considerable step towards improving the rope life, along with the other suggestions I mentioned.

**A. J. Morgan:** I am sorry that I didn't come with a prepared speech. I didn't know that this was the usual procedure. However, there are one or two points which I think are quite pertinent to the paper which you have just heard which, by the way, opens up a subject which I am sure you realize is very important and one which the wire rope manufacturers have attempted in many ways to cover. I might say a word in defense of the wire rope manufacturers, since we have been criticised for not giving certain information.

The reason for that is that we have been confronted with so many different kinds of users. I say that with no reflection whatever, but, as you know, some people neglect certain operations and others pay close attention to them. It is always necessary, in making any general rule which can be used by an industry, to protect the one who will not follow good practice. If we, as rope manufacturers, lay down certain rules and put in certain qualifications as to their use, invariably somebody will not read the qualifications but will take the rule as a definite law, go ahead on that basis, get into trouble as could be anticipated, and then blame us. So I would like to ask you to please understand our position in the matter.

The subject of the proper time of removal for wire rope is one that has interested our company particularly, as well as the other rope manufacturers; and we have endeavored in the last two years to collect and put in usable form information which we have been gathering over a great number of years. We have already attempted to cover the elevator ropes as far as our particular manufacture is concerned. We wouldn't attempt to cover ropes of other manufacture — that wouldn't be the proper stunt at all, and we are certain that the others wouldn't appreciate it. But we have attempted to cover our own particular ropes.

We have also attempted to cover regular lay ropes and lang lay rope will also be covered in the issue of our magazine which will come out probably the first of next month; and we know that such data is usable and is perfectly practical, because we have used it with so many individual customers.

At the present time we are collecting crane ropes; but, due to the lack of business, which a lot of people call by other names, we haven't had very many of the ropes returned. But we do feel that this is perfectly feasible and can be done.

We feel that there is a lot of useful rope life being thrown away, but on this subject we must bear in mind that the safety of the operation is the most important thing. Service is really secondary, and we should get all the service possible with absolute safety. That is the only basis on which our company would attempt to enter into the formulating of any such set of rules.

The subject of proper construction of rope, whether it be soft iron center, independent wire rope center or hemp center, is a matter, many times, for personal judgment; also, the final and governing test is the service test. As Mr. Cramer mentioned, when the ladles were held by the crane during the pouring, we regarded any kind of wire rope center as a necessity. There were many accidents caused by the hemp center letting down the rope, thus allowing it to break at normal operating tensions.

The question Mr. Howe brought up concerning sheaves and the grooves is a very important one, and one which too often is overlooked. The sheaves

should be examined carefully not only in new equipment, but when ropes are replaced. I would venture to say that there are more short-service ropes caused by improper sheave equipment than by any other cause. The question of the equalizer sheave is of extreme importance. The slight motion that the rope makes over the equalizer sheave is such as to fatigue a very short portion of that rope. It is always in the same place—there is no action of the crane whatever to move that spot to another portion. Therefore, you have a tendency to broken wires at a point often inaccessible and usually where the inspector never looks. That is one point which should be the first point and the principal point during any rope inspection on a crane. We are pleased to note that the tendency is to eliminate sheaves, which have always been a problem and a trouble to rope users.

There is one other point which is very apt to enter into this committee's discussions, and that is the proper rope construction to use for most economical service. You have another factor involved which you will have to examine, inasmuch as some of the plants are confronted with a stock proposition. The warehouse stock becomes rather expensive if you buy the construction recommended for service on each of your various installations. It is oftentimes found better to average the rope recommendations so as to cut out a number of stock items. Therefore, some of the rope which you will use will be best fitted for some particular installations and not quite so well fitted for others; nevertheless, there is an economical balance which has already been taken into consideration and which must continue to be considered.

The only thing I can add is that we appreciate the opportunity to present these few views, and it is our opinion that this matter of fixing a time for changing cables can be done safely and economically; but it is necessary to formulate the rules in such a manner that there can be very little chance for misunderstanding.

**H. W. Ball:** Mr. Chairman and members and friends, I think this subject is very interesting and Mr. Cramer deserves lots of credit for sending out this questionnaire and assembling the information received; because I know it means a great deal of work to send all these papers out to the different plants and work up the data and get it into shape for a meeting of this kind.

I checked blue prints of the questionnaire on this subject carefully and on an average, the desirable features coincide with the type of ladle cranes that we are building the present day.

Regarding the question of sheaves, we try to keep them as large as the current designs will permit, and keep the number of parts of rope to a minimum. It will be interesting to find out what the steel mills consider would be the maximum diameter of cables to be used. It has always been a question whether to use one and an eighth or one and a quarter inch diameter cables. We find from past experience that sheaves from thirty to forty times the diameter of the cable used prolongs the life of the cables considerably.

I know of no cranes we build that we take more pride in than our ladle cranes. The spring equalizer is a great help in case of a broken cable.

**W. D. Keller:** I had not expected to enter into this discussion this morning, having merely dropped in as a visitor. I may say, however, that the Alliance Machine Company has given a great deal of consideration to this proposition. We have now in our exposition booth a working model of our latest design of ladle trolley which shows the reeving we recommend. This is now in use by many of the steel manufacturers. We are informed that the adoption of this reeving has resulted in greatly increased rope life.

With this arrangement the so-called safety cables have been eliminated but the total safety factor retained by increasing the number of active ropes. Four separate pieces of cable are used, two being attached to each drum. The equalizing sheaves have been discarded and a special type of equalizing beam used. This beam permits the free equalization of the cables but in case of one cable parting, prevents excessive drop by means of a spring cushioned stop, thus avoiding the destruction of the remaining cables.

The interlocked drum gear type of ladle trolley is now used almost exclusively, and with this type, reverse bends in the cable cannot be avoided. However, the drums are usually excessively large in diameter which makes this condition less serious.

In reference to the suggestion that rope life be lengthened by increasing the size we find that most of our customers prefer cables not to exceed 1⅛" or at most 1¼" in diameter, as larger sizes are very difficult to handle in addition to requiring excessively large sheaves. It is, therefore, necessary, in view of the large capacity and safety factors required in ladle crane construction to resort to a large number of cables and the point brought out in the paper in reference to the use of anti-friction sheaves I think is very important, and I am pleased to learn that they have been generally adopted.

**C. K. Traber:** First, referring to the text of the paper presented I am particularly interested in the statements in the fourth paragraph of the second column. The author of this paper says that improvement in rope service may be expected through a study of the crane design, the use of proper cable dressing, and method of application, and finally comes to the conclusion that the life of such a rope should be better than a year of service. What strikes me here particularly is the fact that the author seems to assume that all rope would give equal service under similar conditions if properly taken care of. If this is his intention I do not agree with him. Leaving out of consideration the possibility of a difference in the manufacturing methods, and consequently the excellence of the product as regards mechanical construction of the rope, and which you must admit might affect the life of the rope, we have to consider the question of the grade of the material used; the source of the raw product of which the wire is made (and which, strange as it may seem, is quite important), and particularly the type of rope as to construction.

As to the grade, I am in favor of using only Improved Plow Steel rope for ladle crane work.

It must not be assumed, however, that the measure of a rope's usefulness is in its remaining strength. A discarded rope should be examined as to the condition of the wire—whether there is any internal corrosion—and which is entirely possible,

although the outer wires show no signs of this whatsoever, and a number of selected wires of the rope should also be examined for fatigue. A rope may test fairly high in tension and still be unsafe rope to use, because a rope with fatigued wires would not necessarily give a low tensile test, but might yield to a sudden shock. Recently a crane rope, ¾ in. diameter, failed—that is, pulled in two—after twenty-two months service. This rope, although it had decreased in diameter some, due both to wear and pulling down, still looked from an external examination to be in pretty good condition. An examination of the inside of the rope, however, revealed that the wires were very considerably corroded, although it had been well lubricated; that is, the lubricant had penetrated pretty well, and all of the wires were well covered at the time of the break. Now whether this corrosion developed previous to the application of this particular lubricant, or whether there was something in the lubricant that caused the corrosion, we have not yet determined. We are now examining into this particular case.

It does seem, however, that eighteen months' service should be considered ample for any crane rope. In one plant the ropes taken off the main hoist after eighteen months' service, are later used as auxiliary ropes, and give considerably more service there. This is a good practice, since the ropes after being taken off the main hoist can be carefully examined, and if they look good internally then the best part can be selected for other use as mentioned.

In conclusion may I say that when I mentioned eighteen months as being probably the maximum period for which a rope should remain in use, and suggesting that this period can be secured by a proper selection of rope, I do not wish to leave the impression that on all types of machines and under all conditions this period of life can be secured. There are many old style cranes on which it is necessary to use the 6x37 construction, and where under the conditions an eighteen months' life would be out of the question. In each case, of course, it must be determined by experiment what is the period after which the rope should be removed.

**W. E. Miller:** Mr. Chairman and gentlemen, this was a very interesting paper, especially for someone who has had many years of experience with ladle cranes; but the way I feel in this matter is that most plants have to work out their own salvation as to the life of these cables or the proper time to change ropes on ladle cranes. It all depends on the age of the crane. If the ladle crane comes up to the voting age, why you can pretty nearly always figure that you've got to subtract a few months from the life of the rope. With the newer type crane, I find you have less trouble; but there are a good many of the old ladle cranes in use.

Using the equalizer beam rather than the equalizer sheave gives the ropes a better chance to equalize, but quite often we find that, after the rope has been changed on the ladle crane, it is not followed up and the ropes adjusted so the equalizing beam will come back into action. We also find that, by changing to these equalizer beams, we add considerably to the life of the rope used on older ladle cranes.

I might add that for Ladle Crane and general Electric Overhead Crane use, the 6-37 stranding has worked out the best in our plant but the 6-19 stranding has worked out better on ore bridge and locomotive cranes where due to the design of the machines, the drums and sheaves are smaller usually considerably under the thirty times the rope diameter.

Sometime ago when due to the times, efforts were made to reduce the number of different kinds and sizes of rope carried in stock we found after a close survey of the plant that it was not economical to use rope not suited for the particular job in order to cut down on the rope inventory.

We have also found that ropes with hemp centers work out the best. The steel center rope was tried out but the uneven expansion between the outer layers of the rope and the steel center caused the outer layers to bulge out. We had to cut the steel center in order to stop this bulging which made an unsatisfactory rope.

**A. W. McAuly:** I am greatly surprised not to have heard mention of the type of rope construction in which the individual wires in the strand have been "preformed" as it is sometimes called. I have read the advertisements of some of these rope manufacturers wherein they claim great superiority for this type of construction over the ordinary rope construction. It seems to me that this sort of rope has been on the market long enough to have proved its superiority. For my own information and that of the others interested, I should like to know how much of this rope is being used and whether there is an actual superiority in this type of construction.

Where we are using ladle cranes for two purposes—that is, where the main hoist is used for handling hot metal and the crane is equipped with an auxiliary hoist, this hoist being used for other work around the plant—we find that the auxiliary hoist is used probably ten times as much as the main hoist; and the main hoist cable has been subjected to a scrubbing and wearing action due to the block swinging around, the main block hanging in its highest position when operating the auxiliary hoist. We found that by installing a bracket under the trolley, this bracket being so arranged that the main hoist could be drawn up into a fixed position thereby decreasing the swing considerably, the life of the main hoist cable was greatly increased. I think that is a point that should be given consideration by the crane manufacturer; and, when the crane is to be used more for auxiliary work than hot metal work, a bracket of this sort should be incorporated in the design of the crane.

**J. A. Voss:** Mr. Chairman and gentlemen, hot metal cranes in the iron and steel industry have always given us great concern both from the standpoint of safety as well as from the standpoint of service. I am, indeed, happy to see our Association undertake this subject and hope that something definite will be developed along this line that our plants can be governed by in the future. At this time I want to pay tribute to the members of the Association, the manufacturers of hot metal cranes, and the wire rope manufacturers, for the attention they have given to this very important equipment. Apparently, the iron and steel industry has profited by the study they have made, and I feel satisfied that, if we continue along this line, our Association will be contributing something to industry that will

be of vital importance in conserving human life and limb. We don't very often hear of a hot metal crane failure;—we don't want to hear of it;—and, from the information and facts that we have on hand covering this type of equipment, there is no reason why we should have any failures on hot metal cranes.

I feel satisfied that, after we leave this meeting today, we are all going back to our various operations and make a careful study to see that our equipment is safe when handling hot metal.

Gentlemen, at this time I would like to recommend that we follow up the survey that has been started to see if we can't develop some uniform method in the changing of hot metal crane cables. In reading the report, you will find that there are many various opinions along this line, and I certainly hope that the Association will not drop the subject until a definite set-up is developed. Let us continue to carry on and see if we can't make this equipment one hundred per cent safe. I feel satisfied that, with the assistance of the crane manufacturers, the wire rope manufacturers, and the members of this Association, that this will be accomplished.

**J. Farrington:** Mr. Chairman and other gentlemen, I cannot emphasize too strongly the elimination of the equalizer. We just escaped about two weeks ago a serious accident on a hot mixer crane. This cable had been installed only twenty-eight days; and, as we were starting to dump the ladle, the cable broke at the equalizer. That had been inspected by our cable inspector and our foreman within eight days. We then tried splicing a larger section of cable where it went over the equalizer sheave; and we were surprised to find that, even with fifty per cent increase at that point, that cable failed again.

So we are starting now a vigorous campaign to eliminate all the equalizer sheaves. We came across a condition that had not come to our attention for some twenty years, of a cable failure in which the outside of the cable showed but very little wear. The cable had been in service on a mill crane for about sixteen months, and we had a failure with it lifting about a normal load; and, upon examining the cable, we found the inside strands crystallized. And I would like to ask any crane builders or cable manufacturers or other members of the Association if they have ever come across that condition. It was a new one on us.

We have been using manganese sheave wheels for quite sometime, and believe thoroughly in the regular inspection of our crane cables, which is covered by our cable inspector. We have one man who does nothing else at the plant but inspect the cables, and he, together with the foreman of the section, makes a weekly inspection of all of our crane cables.

As to the method of lubrication, we have used black oil to a great extent. And another thing we observe is in renewing our cables we take steps to see that those cables are of equal length; so we do not unreel the cable and lay it on the ground as is customary, but reeve the cable straight from the reels, the cable never touches the ground, thereby eliminating the picking up of dirt, as you know your cables are all received with a certain amount of lubricant on them.

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# DISCUSSION
# Mechanical Power Transmission Division*

By J. F. KELLY
Managing Director, A. I. & S. E. E., Pittsburgh, Pa.

Presented before Twenty-eighth Convention of the A. I. & S. E. E. in Pittsburgh, June 23, 1932.

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**DISCUSSION PRESENTED BY**

**J. H. Van Campen,** Chief Engineer, Republic Steel Corporation, Youngstown District, Youngstown, Ohio.
**W. S. Hall,** Supt. Engineering and Construction, Illinois Steel Company, South Chicago, Ill.
**A. L. Foell,** Chief Engineer, Arthur G. McKee Company, Cleveland, Ohio.
**A. J. Standing,** Electrical Supt., Bethlehem Steel Company, Bethlehem, Pa.
**S. M. Weckstein,** Engineer, Timken Roller Bearing Company, Canton, Ohio.
**J. J. Booth,** Electrical Supt., National Tube Company, Gary, Ind.

**J. H. Van Campen:** Gentlemen, we have a new subject this morning, which we desire to present at this meeting, and that is the subject of Mechanical Power Transmission. The thought we have in mind is that there is considerable interest in this particular subject and a discussion of the subject will assist us in the formation of our new engineering division. We believe that after the subject of Mechanical Power Transmission is more fully developed that this division will become one of the most important divisions among those which we already have. I think it will probably be best to get an outline of what this will consist of before this meeting.

**W. S. Hall:** Mr. Chairman, this question has been discussed by our Board of Directors for over a year and the first question I asked—and I think it is probably the one which is paramount in your minds at the present time—was whether or not we

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

are in any way exceeding the limitations of the field in which we are supposed to operate. The first impression that I got was that possibly we were, but the more I think it over the more inclined I am to believe that we should have gone into it sometime ago.

For example, one of the things which we are most vitally interested in is the most common application of power transmission leading from the motor, which is, of course, the reduction gear unit. Many of us recall that in the early stages of the application of motor drives to rolling mills we didn't have these satisfactory gear units. The result is today we have twenty-five cycles in many rolling mills where, if we had these gear units years ago, we wouldn't have that to contend with today. When we are considering the application of a drive, the first thing we have to consider, of course, is the horse-power that is required and the speed. Right away we have two problems to contend with—what can we get in the way of a gear unit, to apply to a certain speed motor. The motor manufacturer wants to know what reduction we are going to have in our gear unit and the gear unit manufacturer wants to know what speed motor we are going to have so he can work out his ratio.

I don't think it is within the scope of the Association to attempt to tell these gear builders, if we are considering gears as one division of this new engineering division, how these units should be built —I think that is farthest from the idea. The principal idea is, to try and work up specifications, similar to what we have developed in connection with the motor manufacturers covering the large motors; so that when a set of specifications covering gear units is delivered from the plant engineer into the hands of the gear manufacturer, he will have a set of specifications which give him all the leeway in the world to develop his own ideas and at the same time embody such points as are necessary for the plant engineer to have to properly analyze the proposal.

If this is accomplished, I think it will be a distinct advantage to the gear manufacturers; because, if they were in a position to see the great variance not only in the nature of the equipment but in prices submitted to purchasers, they would realize that some such movement is necessary to get them more nearly on a common basis. The way it is at the present time there is considerable time lost in getting the manufacturers on a somewhat comparable basis, so that the proposals can be properly analyzed.

I don't know that I have anything further to add, except that I feel that after you've given the question some consideration you'll be inclined to agree with many of us who have thought it over as to whether or not it comes within the scope of this Association to take the initiative on this question. My thought is that we should co-operate to the fullest extent with the Gear Manufacturers' Association. In other words, this is a sort of SOS going out from us to them to help us get these specifications on a basis which we feel is as good as the basis on which our electrical equipment is purchased today.

**A. L. Foell:** Mr. Chairman, I would offer an endorsement of the ideas that Mr. Hall has set forth and perhaps add another thought to what he has already said. The transmission of power is never purely an electrical problem. In general it is always a problem involving both electrical and mechanical considerations since the utilization of power or energy practically always necessitates its final application through some form of mechanical device. In other words, where electrical energy is the source of power the electrical and mechanical problems are closely tied together.

In a general way the most important problem in the matter of power transmission is that of economy in the cost of installation and operation. In some cases numerous individual motor drives are justified in delivering power to various points at short distances apart, but in most cases mechanical means of transmitting power in which a lesser number of motor drives are required makes a very much more economical installation and one equally as satisfactory from an operating cost viewpoint. Very often, however, the matter of distributing power by mechanical means such as line shafting gear drives, etc., to numerous points near to each other is attended by so many disadvantages as to warrant the installation of individual electrical drives at each point.

For the reasons mentioned before, I believe it very important that we as an Association, bring together both the electrical and the mechanical phases of the power transmission problem and treat them as a unit and with this in mind I further believe that a Mechanical Power Transmission Division of the Association of Iron and Steel Electrical Engineers is definitely warranted.

**S. M. Weckstein:** Mr. Foell has very nicely tied in the mechanical and electrical points. I think there is another point which is very important and, in my opinion, justifies this Division's coming within the scope of the Association; and that is the fact that "Lubrication" plays an important part in this problem. We are primarily interested in these gear drives from a standpoint of bearing applications, and still more interested from the standpoint of the lubrication of the bearings as well as the lubrication of the gears. Now that is a very, very important problem.

There has been considerable comment on the methods of isolating or combining the lubrication of the bearings and the gears; and, because of that point and because of the fact that the lubrication is really the controlling factor in the efficiency and the life of the unit, it is very important that it be considered both from the mechanical and the electrical standpoint and be very closely tied in with the lubrication problem.

**A. J. Standing:** What is this Division and what is it going to cover?

**J. H. Van Campen:** Mechanical Power Transmission Division. Gears, couplings, belts, ropes—all the various means of transmitting power.

**A. J. Standing:** Is it confined to mechanical transmission of power?

**J. H. Van Campen:** Yes, confined to that. I feel if we get the committees properly organized for this division we are going to develop a considerable amount of valuable and interesting information that will be a surprise to all of us, and it will be one of the active divisions of this Association. It may be that some of this work will interlock with the Lubricating Division, also the subject of bearings, however, we will endeavor to confine the activities of this

division to only the subject of Mechanical Transmission of Power, at least for a number of years.

**A. J. Standing:** The reason I asked that question is that I think, if we are going into this thing, we ought to go into it right. In connection with the steel plant activities, aside from the pure and simple making of steel, there is no problem that affects our product any more than the transmission or transportation problem. We've got to cover not only mechanical transportation of power, but I think we should get into fuels;—the transportation and transmission of all kinds of gases, oils, tars;—anything that is involved in the transmission of power or fuels should be properly covered by this development.

In other words, the Association's ramifications have got to follow to a certain extent the changing responsibilities in the plant. When we started we repaired motors, and that was about as far as we went. Then we gradually took over this and that; so we accumulated all kinds of activities and responsibilities, and with them comes the transportation and transmission of almost everything that is hauled, piped or transported around the plant. And I think that's got to be correlated through this division to try and get at the best methods of transmitting any kind of commodities around the steel plant.

**J. H. Van Campen:** I believe Mr. Standing's idea is somewhat broader than possibly we have in mind at this particular time. When we speak of transmitting fuels, etc., we enter into the transportation problem, which I feel is a different subject than the Mechanical Transmission of Power. We had in mind, initially, only this particular subject. Offhand, I don't just see how transportation would enter into this picture at this particular time, it may come later. There are a lot of angles to this subject, which of course, we have not analyzed fully. Possibly we do not have as clear a vision of what this whole subject is going to cover as we will have sometime later. By not having that, we are going to run into a lot of very interesting angles which we will possibly have to add to or subtract in order to make this division as valuable to the Iron and Steel Industry as possible.

**J. J. Booth:** Your President and Board of Directors have had this matter under advisement for an entire year and it is indeed very gratifying to us to listen to the general trend of the discussion which has taken place here this morning.

I am sure that the rest of the Board feel the same as I do about this matter and that we have, from the sentiment given, hit on one of the main problems before our Engineering Staff today. With this backing of our Association members, the Engineering Fraternities and the Manufacturers, the Association will proceed at once to the formation of a Mechanical Power Transmission Division and will endeavor within the next few years to correlate a lot of valuable data—valuable both to the application engineers as well as to the manufacturers themselves.

Mr. Hall very nicely expressed the situation when he stated that his thought in the matter was that we should co-operate to the fullest extent with the Gear Manufacturers' Association. It is a sort of S.O.S. going out from us to help us get specifications on a basis which we feel is as good as the basis on which our electrical equipment is purchased today. If we can accomplish this sort of a program, we will have accomplished a great deal.

I am quite confident that our new President and his Board of Directors will make the development of this committee one of their major problems for the year 1932-33.

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# DISCUSSION

# The Behavior of Steel at Forging Temperatures with Respect to Scaling Losses*

By DR. D. W. MURPHY
Research Associate, Department of Engineering Research, University of Michigan, Ann Arbor, Michigan.

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Presented before Combustion Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 22, 1932.

DISCUSSION PRESENTED BY

**T. J. Ess,** Combustion Engineer, Republic Steel Corp., Massillon, Ohio.
**F. H. Loftis,** Engineer, Surface Combustion Corp., Toledo, Ohio.
**Dr. D. W. Murphy,** Research Associate, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.
**H. Dobrin,** Consulting Fuel Engineer, Pittsburgh, Pa.
**J. L. Miller,** Steam Engineer, Carnegie Steel Company, Youngstown, Ohio.
**E. A. Brown, Jr.,** Asst. to Chief Mechanical Engineer, Carnegie Steel Company, Homestead Works, Munhall, Pa.
**F. Burdette,** Combustion Engineer, American Rolling Mill Company, Butler, Pa.
**L. A. Hoffmann,** Engineer, American Tube & Stamping Co., Stanley Works, Bridgeport, Conn.

**T. J. Ess:** Dr. Murphy's answer to the question when is a reducing atmosphere not a reducing atmosphere might interest a lot of us in just what a reducing atmosphere is. Scaling represents a severe loss to the steel industry, and yet it is hard to judge just how far we can go towards the reduction of it. As the slides showed, the matter of a non-scale atmosphere in a commercial heating furnace is al-

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

most impossible. And even if we were to heat without any scale at all, by the time that ingot or bloom hit the mill, it wouldn't look a great deal different from the ingot or bloom that was heated in the ordinary atmosphere. But I'm sure the paper will provoke some interesting discussion. Is there anyone who cares to volunteer in discussion of this paper?

**F. H. Loftis:** I'd like to inquire whether the dollar losses were credited with the value of the recovered scale and whether they also included the fuel used in heating up the amount of steel that was lost?

**D. W. Murphy:** Of course, that table I showed first did not take into account the fact that the scale might be recovered; because, while essentially we can recover the scale by putting it through a melting operation again, still it's an economic loss in the first place.

I don't believe I understood the last part of your question.

**F. H. Loftis:** The question is whether the fuel used in heating the scale is included in that loss.

**D. W. Murphy:** No, the cost of the fuel is not considered. It is simply the intrinsic value of the metal. The chief reason for putting in that table was to show that, even when we consider only the value of the metal lost without any of the attendant evils of scaling, we will arrive at rather enormous figures for the effect of scaling.

**J. L. Miller:** I feel that Dr. Murphy should be congratulated upon the preparation of this interesting paper. It goes into a subject of considerable interest to all of us and one which is a source of a great deal of loss to the industry. The gentleman on my right has brought up the question of the true value of this scale. Much might be said on this subject involving the remelting and rerolling costs in putting this scale back into commercial steel. The data brought out in this paper was of considerable value as well as of interest.

**H. Dobrin:** Mr. Chairman, the question of scale or the elimination of scale is really not to be measured or weighed in the cost of the lost steel, but I am sure that Dr. Murphy intended to bring out the point that it has to do with the quality of metallurgical heating. Very often, even if you could save the money involved in the scale itself, that wouldn't be the main object to be desired. It very often is a question of your making a poor sheet or a spoiled sheet—it's going to be a second or it's going to be discolored or have a broken oxide. So, for the very purposes that I am sure the author wrote the paper, I think he intended to bring out something which is becoming recognized very much now as an important phase of metallurgical heating. The people who are heating for quality and not for quantity, and not for tonnage but to produce a certain kind of product, purposely employ a very highly reducing atmosphere, for instance, if you make a high-grade, full finished sheet. Also if you make a sheet for enamel or for furniture.

This is something which is not generally known, but in some organizations the operating department does know what it wants. They will call for, say, 5%. Now they don't know themselves what 5% is, but the superintendent of the sheet mill has learned to ask the combustion department to so manipulate the furnace that it will give a resultant product of combustion containing 5% CO. He has learned that he has to do that. Otherwise, the defect in the product will show up, maybe in the third or fourth process later on.

Furthermore, as to my own comment on the paper, Mr. Chairman, I believe that this paper really has to be studied, and carefully studied, to get the most good out of it; and Dr. Murphy certainly has contributed a very valuable paper. I feel that the Society should thank Dr. Murphy for the time and effort that it took him to prepare such an exhaustive paper.

**E. A. Brown, Jr.:** I think any contribution on this subject is worthy, and Dr. Murphy has especially well presented his.

In spite of not crediting the loss with the recovered scale value, I venture to say that the losses are very largely underestimated, for this reason: When you consider the large volume of structural, tank car, low-carbon steels that are heated that will stand sweating or running, and that the practice a good many places is to let them sweat and run, you've got to take the study out of the laboratory and get into the actual mill operation. In all soaking pit work where the contact of steel against adjacent pieces will not prevent running, sweating can carry off a number of coats that the laboratory might not possibly bring out.

The same thing is true on dry scale heating. When most steel at heating is brought up to the proper temperature, the mill is not ready to use it. It will go back and, in the subsequent reheating you will break off a coating. It was not the intention of the paper, evidently, to go into the fuel losses occasioned by scaling; but they should be considered along the same line in summing up the losses for scaling. Heavy scale losses almost invariably carry with them heavy fuel losses also.

**F. Burdette:** I think this paper contains information which all of us are glad to have, and I hope that at some future date similar research will be carried out to determine the cause of scaling of different natures—how to control the adhesion of scale and the ease with which scale can be broken from the steel.

**L. A. Hoffmann:** I have been very much interested in the paper just presented and in the remarks of the previous commentators who dwelt upon the need of a practical test when it comes to the question of waste through scaling.

There have been born in the course of the last five years numerous companies proposing various kinds of scale resisting material. I'm not thinking in terms of scale losses in heating furnaces, but I'm thinking in terms of that equipment that goes with the construction of furnaces—soaking pits, annealing covers—matters of that sort. These numerous materials reach well into the hundreds, with the result that at the American Tube and Stamping Company plant at Bridgeport, Conn., we have formulated some tests that are now in the course of three thousand

hours of practical service passing through furnaces. These pass through in the ordinary course of operation, checks being taken upon the weight, nature of scale, the characteristics of the scale, and the fracture appearance of the virgin metal when broken following the completion of the test. It has been very interesting and a matter of education to those of us who have formulated and conducted these tests to note that there are five or six very distinct kinds of scaling. Some scales lift off and flake. Some scales scab. Some scales are very progressive.

Possibly one of the most interesting types of scale that has come to my attention occurred in a sample which stood 2500 hours of heating. It took less than 150 hours of subsequent heating for the entire destruction of the sample, which showed a diminution of but three or four ounces in forty pounds during the 2500 hours and lost a matter of ten pounds in the subsequent 150 hours. There is a very distinct internal reaction taking place, apparently.

We don't know enough about these matters, gentlemen. There are other scales that are smooth and velvety on the surface but which penetrate and go in on a three-eighth inch section as much as an eighth or three-sixteenths of an inch.

My reason for making these remarks, gentlemen, is to bring out the need of correctly interpreting laboratory tests. I do not belittle in the slightest laboratory tests. As one who has received training with the Bureau of Standards, I hold laboratory work in high esteem. We must not, however, forget the practical application of these tests—their use in industry.

The tests I refer to have been made with some 40 different samples, involving, I think, 29 various kinds of trade mixtures in the heat resisting field.

**A Member:** I'd like to ask Dr. Murphy if there is any difference noted between the action of free sulphur and sulphur dioxide in this test? And I'd further like to ask if these data can be used at temperatures below 1700.

**D. W. Murphy:** Of course, the data was derived from temperatures of 2000 to 2500, and the scaling that occurs in the heat treating range, which is what you are speaking of, presents some rather different characteristics than that which is found in the scaling and forging range. For instance, the paper which will be given this fall before the American Society for Steel Treating shows some rather interesting characteristics in the pure gases. If we plot the scaling loss vertically and temperature horizontally we find that progressing from lower to higher temperatures for air there occurs a sharp decrease at 1800. There, an increase in the rate of scaling occurs at 2000. This, of course, was not found in our research from 2000 to 2500. This is only one instance in which the data obtained in the forging range cannot be extrapolated below the temperature at which it was obtained. This (drop in the curve) I might say is caused by blistering.

I would like to thank the Association for their cordial reception of this paper, and I thoroughly agree with the remarks of Mr. Dobrin, who stated that we can't simply take the economic loss of metal involved in scaling as an adequate measure of the importance of the problem. I have endeavored to bring that out in the second or third paragraph of the paper—where I say that the total effect of scaling is dependent upon several other factors that are very difficult to estimate—factors such as the number of rejections out of the total production and so on. Of course, such factors will vary in any plant depending upon conditions, and I have made absolutely no effort to compute their possible magnitude.

The question of different types of scale did not come into this research as much as it does at lower temperatures. We found, as a matter of fact, very little difference in the composition of the scale in the range from 2000 to 2500, although there was some difference in the adhering characteristics of the scale. For instance, it was found that scale formed in carbon dioxide atmospheres was more adherent than that formed in steam. The steam scale peels off rather readily and in very large chunks, while the carbon dioxide scale comes off in small flakes and a good bit of it adheres to the metal after quenching. That question of scale characteristics is a very important problem, and I believe will need a great deal of further research to tie it down.

When it comes to interpreting laboratory results for plant practice, of course, we have got to take into consideration a good many conditions; and I might say that all the work that was done for this research was done on round samples, and that we didn't investigate very fully the effect of varying the shape of the sample on scaling losses. It is quite conceivable that when you vary the shape, that is going to a thin slab, for instance, the scaling losses will increase; because the surface-mass ratio becomes very decidedly different from what it is in a round bar. That is a question that I believe could be correlated if we take into consideration the surface-mass ratio as a factor in scaling loss.

The heating of billets and so on when you heat to a wet scale is a condition where the oxides are molten. For that the temperature must be in the neighborhood of at least 2500 degrees, Fahrenheit, and the chances are it's higher; and, of course, under those conditions the losses are vastly greater than those which I have placed in the first table. That will require probably a separate estimate, depending upon the shape, the time, and so on, and the temperature of the specimen.

I think the results do, however, indicate the path along which we could go to improve our existing furnaces—improve their operation—so that we can avoid undue scaling. Perhaps we can't eliminate it entirely, but we can avoid excess amounts.

# DISCUSSION

# Compensated Motors and Generators*

By M. E. THOMPSON
Consulting Engineer
and
I. S. NIPPES
Electrical Engineer, Elliott Company,
Ridgway, Pa.

Presented before the Electrical Engineer Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 22, 1932.

DISCUSSION PRESENTED BY

**R. H. Ellis,** Electrical Engr., United Engineering & Foundry Company, Pittsburgh, Pa.
**H. A. Winne,** Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.
**M. Hartenheim,** Consulting Engineer, Pittsburgh, Pa.
**C. Lynn,** Power Engineering Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
**G. E. Stoltz,** Manager, Mining and Metal Working Elec. Sec., Industrial Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
**W. H. Burr,** Electrical Supt., Lukens Steel Company, Coatesville, Pa.
**I. S. Nippes,** Electrical Engineer, Elliott Company, Ridgway, Pa.

**R. H. Ellis:** We as mill builders are extremely interested in the fact that DC motors are being built with better regulation than they have been in the past. We are not in position to build these motors, but are certainly interested to hear from the manufacturers telling us just how good these machines can be made. Therefore, it would be interesting if some of the men would give us some figures as to how good the present-day machine can actually be built.

**H. A. Winne:** I think the authors of this paper are to be congratulated on presenting in a very able manner the many advantages of compensating windings on D.C. machines. There is no question as to the beneficial effect on commutation of compensating windings, and as electrical manufacturers we use it on all machines which are hard worked from the standpoint of commutation. However, we do not consider it good engineering to put a compensating winding on a machine such as a slow speed engine driven generator, or even a slow speed hoist motor, any more than we would think of putting a 40" by 10" tire on a 1-ton truck. Such slow speed machines will easily commutate any overloads which they may be called upon to carry, even though they have no compensating winding, and the use of a compensating winding is not without some disadvantages.

To get good commutation a certain number of ampere turns are required, either around the commutating pole, or in combination around the commutating pole and in the compensating winding. The total number of ampere turns must be approximately the same in either case, but it is obvious that the length of turn around the commutating pole alone is much shorter than the average length of turn through the compensating winding. Consequently, as a rule, putting a compensating winding on a machine means a slight increase in copper losses.

One feature which should not be overlooked is that the main purpose of a compensating winding is to neutralize the cross magnetizing action of the armature winding. This being the case, it is obviously desirable to get the compensating winding as close as possible to the armature winding and, therefore, we make it a practice to make the conductors through the pole pieces as shallow as possible and get them close to the face of the pole, thereby, bringing the compensating current as near to the armature conductors as we can. Furthermore, the use of the comparatively shallow compensating conductor permits the main field coil to be brought down very near to the armature, and this in turn prevents excessive fringing of the main field flux.

Mr. Ellis asked what speed regulation could be obtained from D.C. motors. I think the curve shown by the authors of the paper in Fig. 8 shows a speed regulation of approximately 5% at basic or full field speed, and 6% at 300% speed. We have found that we can, without difficulty, design a main roll drive motor so that, without the use of series exciters or regulators, we can obtain a full load speed regulation of not over 2% at the top speed, and not over 6% at basic speed on a 3:1 speed range machine, or 4% at basic speed on a 2:1 speed range machine. The greater percentage regulation at lower speed results in the same number of r.p.m. speed drop; or, in other words, if you are thinking in terms of metal speed in a continuous mill, it means about the same number of feet per minute. If series exciters or regulators are used, of course, closer regulation can be secured.

**M. Hartenheim:** I should like to add a few remarks to the information the speaker has given about the development of the compensated machine. I had the good fortune to be connected with the first electrifications of rolling mills and reversing mill drives in Europe and to design some of the earliest and also later compensated generators and motors. At that time it was thought that the compensated machine would solve all the difficulties involved with this type of electric machine, but soon it was found the compensating winding alone could not do it as also the armature winding plays a very, perhaps the most important part in the performance of a dynamo.

It is the general practice in this country to use loop windings in the armature windings of large

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

machines, that is, all armature circuits are connected in parallel and the winding progresses from one commutator segment to the adjacent segment. It is unavoidable that in this way the different armature circuits, usually same in number as poles, are slightly different either by magnetic influence or by resistance, brush contact resistance, soldered joints, etc., bringing this about, and although the cross-connections equalize these differences for all exterior purposes they still persist in reality in the armature itself. Now even a theoretically absolutely correctly devised compensating winding compensates the armature reaction only as a whole because for practical reasons there are never as many parallel circuits in the compensating winding as in the armature winding, and therefore the non-uniformities in the individual armature circuits are not compensated for by the compensating winding. When this was found out not the plain loop winding but the so-called series-parallel winding (or Arnold winding after Prof. Arnold, its inventor) was employed extensively in Europe with great success. Unfortunately, this winding is here not so familiar as it rightly deserves, it is more difficult to calculate and also not quite so simple for the shop as is the loop winding; it would take too long to go further into this matter, but I want to point out that the individual differences between the parallel circuits are almost entirely eliminated as the conductors of one circuit are not subjected, as in the loop winding, to the influence of its respective pole only but to that of all poles.

Several years ago, also at one of these conventions, the armature winding and its bearing on machine performance was discussed and a new winding described but in general more attention was paid to the compensating winding. The speaker remarked rightly that compensating a machine is not a cure-all, but it can be said very properly that a correctly devised armature winding makes a machine much less sensitive to the unavoidable differences in the individual parallel circuits due to material and construction, and thus contributes essentially to the satisfactory and reliable performance of machines with such rigid requirements as we make on them in our steel plants.

**C. Lynn:** To those familiar with the art, it is recognized that the commercial development of D.C. motors and generators has gone through three distinct stages: First, the non-commutating pole machine; second, the commutating pole machine, and third, the compensated machine. Each of these classes of machines has had and will continue to have a specific field of application.

The simplicity and cheapness of the non-commutating pole machine still leaves a field for its use at the present time in such service as small size motors and generators, slow speed elevator motors of even the largest capacities built today, and in certain other applications where simplicity and cheapness of cost are of prime importance.

The straight commutating pole machine has had and will probably continue to have the largest field of application in the direct current motor and generator field, because it has all the requirements necessary for general application without the accompanying complications and added cost of compensation.

The compensated machine has its widest field of application in machines of large size and high speed, where severe overloads are encountered, where variable speeds are necessary, and where extremely flat voltage or speed regulation is demanded. The compensated machine in itself has some characteristics that are detrimental. For instance, a flat voltage regulation is secured at the sacrifice of division of load in installations where two or more flat compound generators are operated in parallel, and special precautions are sometimes required, such as adding differential series fields, in order to secure satisfactory division of load between two or more of these generators operating in parallel. This is because in compensating a generator, the overcoming of the armature magneto-motive force by the magneto-motive force of the compensating field winding has relieved the generator of its inherent drooping voltage characteristic, which characteristic is necessary for proper division of load.

A simple way to consider the compensating winding is to think of it merely as a commutating pole winding with part of the turns taken off of the pole and spread out in the pole face slots. As such, these turns, which have been removed from the commutating pole winding and placed in the pole face slots, still surround the commutating pole and are as effective in producing useful flux through the commutating pole circuit as they would be were they directly surrounding the pole. These turns lying in the pole face do not produce any leakage flux from commutating pole to main pole, and thus relieve the commutating pole from carrying this extra burden of leakage flux in addition to the useful commutating flux. By reducing the amount of leakage flux, more useful commutating flux can be carried, and thus the commutating pole will not become saturated until much higher loads are reached. Since the leakage flux may at times of overload amount to two or three times the useful flux, it can easily be seen that a reduction in the leakage flux will appreciably increase the overload commutating capacity of the machine under high load conditions. This is the main reason for compensating a machine that has to carry high overloads. From a consideration of these facts, it is apparent that good commutation at heavy overloads necessitates the use of a large commutating pole to carry the commutating pole flux (and whatever leakage flux is present), so as to secure good commutation. This commutating pole should also extend back to the frame of the stator, in order not to overload the main poles. It is also necessary that the commutating poles be tapered on machines such as reversing steel mill generators or other machines of the same class that have to carry high peak overloads, as the flux in the commutating pole increases near the back of the pole, due to the leakage. This requirement necessitates the use of a fairly large pole pitch—that is, distance from the center of one main pole to the center of the next main pole in a circumferential direction, in order to have room for the large commutating pole body and to have the main poles sufficiently far away from the commutating pole to minimize leakage flux. At the same time, this gives a fairly large space over the armature periphery through which commutation can occur. On one particular design machine built by our company, the circumferential width of the commutating pole is practically one-half the width of the main pole body. This machine has

carried for short durations 10 times load without any visible sparking and 18 times load without flashing over when the circuit was opened with an ordinary low speed breaker. In this connection, when speaking of extreme overloads carried by machines, it is necessary to state how the machine is loaded at its rated load, because it is very easy to carry high percentage overloads on machines by simply de-rating the machine. In this case, this particular generator has a temperature rise of 25 degree Centigrade at full load. Since for medium speed and high speed machines the armature temperature will reach approximately 90% of its ultimate temperature in 10 to 15 minutes, and since the armature coil heating of a machine carrying 500% load is 25 times the normal heating, it can be readily seen that no normally loaded generator can possibly carry 5 times its name plate rating for 10 or 15 minutes without serious damage from over-temperature, whether the generator is compensated or not.

The remaining function of the compensating winding is, as has been brought out in the paper, that of neutralizing armature reaction and maintaining a practically non-distorted flux form under the main pole. This is necessary where a good voltage regulation is required, unless special precautions are taken. For instance, it is possible by using large main pole air gaps and cut-off pole tips to minimize the affect of armature distortion in a non-compensated machine and obtain a good voltage regulation, even at high overload.

A few years ago, our company built a 250 K.W., 115 volt, 1000 R.P.M. commutating pole, non-compensated generator, whose voltage from no-load to 100% overload did not vary more than 1%, and this generator had a measured temperature rise on its armature of 40 degrees Centigrade at full load.

In connection with variable speed field controlled motors, as used in continuous steel mill drives, having speed ranges of from 2:1 to 4:1, it is necessary to use compensated motors, particularly in the larger sizes, in order to overcome the high voltage per bar due to armature distortion at weak fields, and to obtain good speed regulations over the entire speed range. Even when using compensated motors, the speed regulation at various speeds over the range will not necessarily be exactly the same with one setting of the series field, and it is for this reason that series exciters are sometimes supplied, so that the series field strength can be easily and simply controlled to give the desired speed regulations at all speeds over the range.

In order to have a fully compensated machine it is necessary that there be as many slots with corresponding conductors in the pole face as there are in the armature surface covered by the pole. Since this condition cannot ordinarily be met in practice, and since it is harmful to have a 1:1, 2:1, 3:1, etc., relation between the armature slot pitch and the compensating slot pitch, as this gives a maximum change of reluctance with rotation and produces magnetic noise, it is necessary to use as many slots as possible per pole and to vary the slot pitch to suit the individual armature design, in order to approach as close as possible to the ideal condition. Where only a few slots per pole are used, the wave form will be very ragged and it is impossible to approach the ideal condition. The compensating winding in itself introduces complications, in that it is an addition to the machine and makes the machine less accessible. However, some manufacturers have provided a maximum degree of ventilation and accessibility by making the compensating winding and end connections as open as possible and providing a construction that can be dismantled between poles, permitting the lifting of the top half of the stator, for inspection or removal of the rotor.

In conclusion, I wish to point out that the compensating winding is not a cure-all for all the evils encountered in D.C. generators and motors, but that it does have a particular field of application where it and it alone can serve, and there are other applications where its use is economically unjustified.

**G. E. Stoltz:** I want to commend the authors of this paper for their comments on a very interesting subject and one that manufacturers have given a great deal of study.

In reading this paper, considerable discussion is confined to reversing drives having full field on the motors and later on it is mentioned that in certain drives the motor fields are sometimes weakened. It will be found the majority of reversing drives have weakened field operation and the number that operate on full field at all times is limited. Whether or not the motor has full field all the time or weakened field depends on the schedules rolled on the mill. In most cases the torque required at the higher speed is considerably less than that required during the early passes at slow speeds. The characteristics of the motor applied are made in accordance with this requirement. I have in mind certain drives where motor field is not weakened on roughing plate mills where rolling torque is practically the same throughout all passes made from start to finish. Higher speeds are obtained by weakened field not because the full speed range is not possible by generator control alone, but because we have tried to conform to the torque requirements during the rolling schedules. When we find the torques at high speeds are much less than at lower speeds, the natural thing is to provide generator control up to the point where the torque begins to drop off and then weaken the field of the motor.

Where the motor field is weakened a compensated generator and motor is not only desirable, but practically a necessity. However, on a reversing drive it by no means is the only answer to having successful operating equipment. Our engineers look on compensation as a design feature and not an application feature. The commutating problem on the motor is generally more severe on a motor that is operated with weakened field than one that is not, and on these weakened motor field applications I believe it can truly be said that the commutating problem is more severe than on the generator. The greatest problem occurs at the instant of reversal. A motor having full field speed of 40 r.p.m and maximum weakened field of 120 r.p.m. while running at 120 r.p.m. is operating at one-third full field. If the voltage between commutator bars were limited to 15 volts and if the field were brought up to full field, instantly, it would have a voltage between bars of 45 volts. This would be impossible, of course, and the machine would flash over. We have to consider the time constant of the machines and possibility of including certain devices that would protect

the machines at the instant of sudden change of field flux. If we give machines a very slow time constant or slow field, there might be no necessity of including additional features to protect it. In other words if the operator were to apply full field current to a motor with slow enough field, it could physically slow down from 120 r.p.m. while the magnetic change were taking place.

Several designs of frames have been applied on reversing generators. One of the earliest we used was a laminated frame instead of solid cast steel frame we used at that time on standard machines. The time constant of the laminated machine was so fast that we had to include certain characteristics in our control to retard the rate of change in flux. We found that a more nearly standard type was better than this special laminated field.

The same thing is true on continuous tandem mills where it is necessary to obtain flat speed regulation over a fairly wide range. The maintaining of this flat regulation depends not only on the motor but also on the control and time constant of the exciter.

**W. H. Burr:** I think Mr. Nippes is to be complimented on the very simple manner in which he has handled this problem which has been bothering both the manufacturers and operators for a great number of years. It is a good thing to give consideration to the development of the compensating windings which are being supplied on motors of modern design. On some of the equipment designed years ago, with the insulation materials which were then available, the addition of windings meant in some cases additional maintenance, but with improved insulations and improved design, this has to a large extent been eliminated.

**I. S. Nippes:** I agree heartily with the last speaker that the armature winding is a very important part of a machine and I am going to close this discussion in just a few words by comparing it to a baseball team, having the field and armature to represent the battery; we must have a good field as a pitcher and a good armature winding as a catcher in order to make a good machine.

In presenting this paper we have aimed to confine its scope to broad and basic principles of compensated machines, have not entered into details of design as this would have been carried us far beyond the scope of the present paper. For that reason we have not specifically replied to the open discussion of the paper, since that discussion related very largely to design details, and these details vary widely in machines as designed and built by the different manufacturers of the compensated type of machine.

# DISCUSSION

# Determination of Motor Capacity for Main Roll Drives*

By H. A. WINNE
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Presented before the Electrical Engineering Division of the A. I. & S. E. E. at the Twenty-eighth Convention in Pittsburgh, June 22, 1932.

DISCUSSION PRESENTED BY

**A. F. Kenyon,** General Engineer, Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa.

**W. E. Miller,** Electrical Supt., Bethlehem Steel Co., Johnstown, Pa.

**A. J. Standing,** Electrical Supt., Bethlehem Steel Co., Bethlehem, Pa.

**W. S. Hall,** Supt. Engineering and Construction, Illinois Steel Company, South Chicago, Ill.

**F. Waldorf,** Pittsburgh, Pa.

**H. A. Winne,** Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.

**J. Farrington,** Electrical Supt., Wheeling Steel Corp., Steubenville, Ohio

**A. F. Kenyon:** Mr. Winne's paper describes very clearly and in considerable detail the methods of making power tests, and the several steps necessary in using such test data in the determination of motor ratings for new mills. The power curves for the various types of mills, and for rolling various sizes and classes of products, should be of real value to rolling mill operators by enabling them to estimate mill power requirements, and in stimulating them to collect and publish similar data on other types of mills. Mr. Winne has covered his subject very thoroughly, and my comments will serve to emphasize some of his remarks, rather than to take issue with him.

Mr. Winne has mentioned the effect of temperature on the power required to roll steel, and particularly refers to the temperature of the steel as it comes from the furnace. It may not be out of place to mention that previous to the first one or two passes through the mill, the scale on the surface of the bar, formed by oxidation in the reheating furnace or in travelling from the furnace to the mill, often prevents accurate observation of the temperature of the steel. Much more accurate and consist-

* Paper appeared in the June, 1932, issue of the Iron and Steel Engineer.

ent temperature readings can usually be made after the scale has been cracked and blown off. I also consider it desirable to take readings of the temperature after each pass if possible, or at least at several points during the rolling, as the arrangement and spacing of the mill stands, rolling speeds, etc., all affect the progressive drops in temperature, and hence the energy consumption.

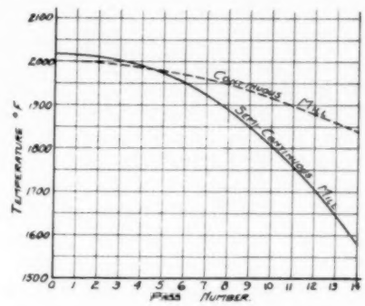



FIG. 1.

On Figure 1, the upper dotted curve shows the temperature of the steel after each pass, rolling ¼" rounds on a continuous mill, while the lower solid curve shows the temperature after each pass rolling the same product in a semi-continuous mill where the steel is looped from stand to stand beginning with the ninth pass. The lower rolling temperature naturally makes the power requirement of the semi-continuous mill much greater than that of the continuous mill, and hence the same power curve would not be applicable to both mills.

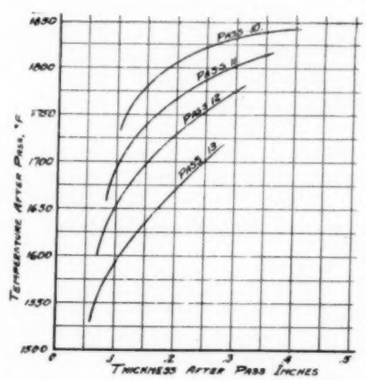



FIG. 2.

Figure 2 shows some interesting temperature data taken from a semi-continuous hot strip mill, indicating the effect that the number of passes to make a given elongation may have on the finishing temperature and hence on the energy consumption. This particular mill consists of thirteen stands, arranged in two parallel tandem lines, and the steel is transferred broadside and its direction of travel reversed between the 7th and 8th passes. The reductions are moderately heavy when rolling .060" thick strip from 3" thick reheated slabs. From the lowest curve it is noted that the .060" thick strip is finished from pass 13 at about 1530°F. When rolling on this schedule the thickness after pass 10 is about .110", and from the top curve the temperature is seen to be about 1740°F. However many orders call for strip up to about .250" thick, and the drafts are lightened to reduce to the finished thickness in the same thirteen passes. It is now seen from the lowest curve that .110" thick strip will be delivered from stand 13 at about 1600°F, or 140°F lower than if rolled in ten passes.

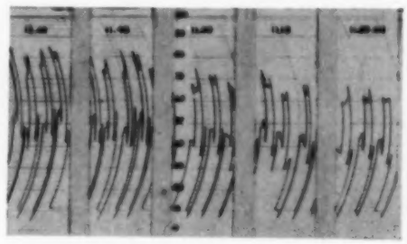


FIG. 3—Load Curve. 8" Semi-Continuous Merchant Mill — No. 2 Motor. Showing increase in load due to drop in temperature of steel.

Figure 3 shows five sections of a graphic ammeter chart showing the input to one of the motors driving a small merchant mill. At 11:00 o'clock the mill was started after a shutdown of some duration, so that the steel in the reheating furnace was at a high temperature and hence the power demand was relatively low. After three-quarters of an hour of continuous rolling, the furnace was emptied of the hot steel and was unable to maintain the earlier temperature. This lowered temperature of the steel increased the peak load about 30%, and taking into account the constant friction load, the net rolling power increased more than 35%. These charts serve to illustrate a condition which Mr. Winne mentioned in his paper.

In making power tests it is essential to record the analysis of the steel, as the presence of carbon and other alloying elements may greatly increase the rolling power over that of low carbon steel. This effect is usually slight at high temperatures, such as in rolling ingots to large blooms, or for the first few passes on reheated blooms, but may increase the power requirements by as much as 50% or more during the finishing passes when the temperature has dropped. In many cases also, high carbon or alloy steels cannot safely be heated to as high temperatures as soft steels, which special condition may have to be considered in the selection of motors for a mill to roll alloy steels. In Figure 4, the lower

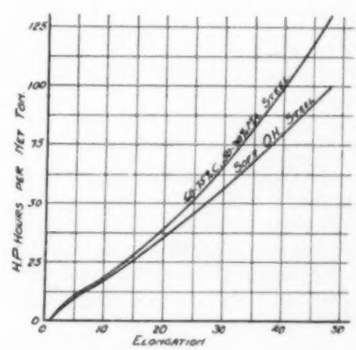



FIG. 4.

power curve was plotted from test data obtained when rolling 3" thick soft open hearth steel slabs to .060" thick strip on a semi-continuous mill, and the upper curve was plotted from data on the same mill when rolling steel with .60 - .75% carbon and .50 - .70% manganese. It is seen that the alloy steel requires nearly one-third greater total energy to reduce 3" thick slabs to .060" thick strip than does the same elongation of the low carbon steel. Note that Mr.

Winne's Curve 10 lies between the two curves of my Figure 4.

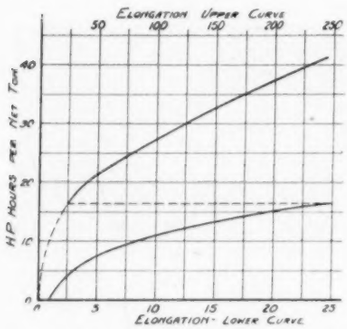



FIG. 5.

It is stated in the paper that Power Curve 3 is for rolling .41" x 8.125" bar from unreheated 8"x8" blooms which come directly from a blooming mill starting with 25"x30" ingots. The elongation scale is on the basis of the 8"x8" bloom as the initial section. Actually, however, the initial section goes back to the 25" x 30" ingot, and the elongation before the first pass in the bar mill is already $\frac{25 \times 30}{\quad}$, and after the last pass is .41 x 8.125 or 225. Assuming now that the rolling of the 25"x30" ingots in the blooming mill requires the same unit energy consumption as the rolling of 22"x24" ingots, we observe from Power Curve 2 that the rolling to 11.7 elongations requires about 11.8 horsepower-hours per net ton. We may then construct Power Curve 3 as an extension of Curve 2, the beginning point being at 11.7 elongations and 11.8 horsepower-hours per net ton, and extending up to 225 elongations and 11.8+27.6=39.4 horsepower-hours per net ton. My Figure 5 shows such a combination of Mr. Winne's Curves 2 and 3, and this new curve will now cover the combined rolling in the blooming mill and the continuous bar mill, and will serve with reasonable accuracy for calculations where the bar mill receives blooms of various sizes from the blooming mill to roll into various sizes of bar.

**W. E. Miller:** I wish to compliment Mr. Winne on the paper he has presented before this Association this morning and also Mr. Kenyon for his discussion, Mr. Kenyon cleared up some of the questions I had in mind.

I do not think the steel mill operating men pay enough attention to the temperature of the steel entering the rolls. They seem to be interested mostly in tonnage produced. This is only natural since they are paid on the basis of tonnage produced and they try to get every thing through the mill that they can.

However in doing this they often put steel through the mill at too low a temperature with the result that much more power is required to roll it and the quality of the product is greatly impaired. If the temperature of the steel could be so interlocked that the operating men could not roll it unless it was at the proper temperature a much better product would result and the power consumed would be lowered.

Another point that I would like to bring out pertains to the design of the rolls. New sections are constantly being devised, many of which are complex in shape presenting many difficulties in their rolling. The number of these sections is far greater than the ordinary person would suspect.

In the design of the rolls for these sections it often happens that the power required on one or two passes is excessive and stickers and other delays result. This excessive power is caused either by too much reduction in size for the passes or too much change in the shape of the material in the pass. A little more attention on the part of the roll designer to the power requirements for the individual passes would bring better results.

**A. J. Standing:** Mr. Winne has not only amplified but simplified the available data which we have at hand on this subject. I hesitate to discuss data so complete but there are certain features which affect the operating engineer that might be discussed under three classifications.

**First—Application of a motor to a new mill.**

This problem can usually be attacked with considerable assurance. As a rule you can secure sufficient data as to what the management proposes to do to enable you to pass intelligent information on to the manufacturer.

One or two limiting features have been mentioned as affecting the probable size of the drive and these were availibility of steel, heating capacity, etc., but there is another important consideration that has not been mentioned and that is the limitation of the mill by the facilities provided to dispose of the product leaving the mill.

Another factor greatly affecting the drive is the interchange of sections from one mill to another. A small section on a larger mill may become the top section on a small mill and crowd the drive.

The addition to an existing mill of improved facilities for disposing of the product such as rod coilers may result in a greatly increased load demand on the drive. We have a case of this kind and we may have to resort to artificial cooling of the drive.

**Second—Transfer of motor driven mills from one plant to another.**

This may seem a simple job, but as a rule mills are not transferred on an existing basis. We were called on to take an 8" bar mill and superimpose it on a 16" x 12" continuous mill, putting four stands of 10" roughing after our 6 stands of 16" roughing and adding 3 stands of 8" finishing following our 4 stands of 12" finishing using existing drives wherever possible. This made a very interesting layout and while it was not finally installed, I think we would have had a satisfactory operating combination.

**Third—Replacing of Steam Driven Mills by Motor Drive.**

In considering this problem several things have to be reckoned with: First—Why are they replacing the steam drive? Possibly because it is obsolete and is at a point where it must be replaced as a unit. It may involve replacing the engine and going ahead as is; or replacing the steam engine to increase the product of the mill. The question of speeds always enters into the problem and affects the answer.

First—On an existing mill the stands, housings, voltage or steel finishing end may be the factors determining the size of drive you can apply.

Second—Availability of power. The provision

which is now made for supplying power to the mill may render it impossible to further speed up the product of the mill. By replacing the engine as a drive, you may have to virtually replace the whole mill and enlarge the auxiliaries leaving the mill.

Wherever possible we get all the manufacturing data available, but in the case of transferring a mill from one place to another the time permitted may be very brief. Mr. Winne mentions getting a proposal on Monday and requesting the information on Thursday. We sometimes receive the word that "there will be a meeting tomorrow to discuss possibilities." That is expecting faster results than we expect of a manufacturer. In anticipation of answering such questions asked by the management, we use collected data and arrive at a sort of an educated guess and leave enough leeway so we know we will be able to do it within that figure, and then we are able to talk to the manufacturers.

**W. S. Hall:** There is no question that sufficient data based on actual operating tests is available for accurately determining the size of a motor required to roll a certain product. In the case of a steam engine on an existing mill being replaced with a motor the problem becomes comparatively simple as the product of the mill in the past years of operation can generally be used as a criterion of what will be required in the future. The problem is not quite so simple in the case of a proposed new mill for, while the mill may be planned for a definite product, what it may be called upon to produce in years to come is exceedingly indefinite both as to nature of product and tonnage.

Little or nothing can be done to increase the capacity of the motor when once installed, while additional heating and finishing capacity can generally be readily added which may eventually make the motor the determining factor of the output of the mill. This point is mentioned in connection with this paper with the view of pointing out the importance of carefully considering, as far as possible, the eventual requirements of the mill.

**J. Farrington:** Both our 45 in. blooming mill and 60 in. hot strip mill were equipped by General Electric and I judge Mr. Winne had considerable to do with the calculation of the size of those motors. The vertical rolls on the blooming mill were designed for a certain condition. At times, as was pointed out, a heat is made for a certain size rolling and when it comes to be rolled we find specifications not quite right, which throws additional work on the edging mill. That motor is now 1650 H.P. and we could use readily 3000 H.P. motor. On the hot strip mill, the two 4-high stands immediately following the roughing stands get considerable overload. Those motors are 1250 H.P. and could very nicely be rated 2300 H.P.

I want to emphasize what Mr. Hall brought out, viz.; when a mill is to be designed to get the rolling mill man to give you the ultimate sizes he expects to roll, then take 10% leeway on gauge and 20% leeway on temperature. Because, invariably, when we get an inquiry that is a little bit thinner gauge than we have been accustomed to, they will say let us try it, and on a mill that is designed for a minimum of .06 we rolled .04. Again we get a specification for steel to be rolled at a temperature of about 200° on finishing stand No. 11, lower than we normally had been rolling and we are not prepared for it and it gave an overload on the mill. Must hand it to G.E., although the machines were 100% overloaded they were able to take care of the increased load.

The matter of temperature has been brought up before. We have a demand limiting device consisting of a warning light to tell the roller he is approaching his limit, and in case he does not heed that warning, a relay to shut off his power. We can pretty nearly tell by the number of amperes what was the temperature of the ingots when he was rolling. He knows his ingot is getting cold and will not continue until he gets his rolling signal. We do not care to shut the hot strip mill down, so give warning to the furnace man showing that they are exceeding the demand and if they do not heed the warning a relay stops the furnace man from pushing another heat out onto the table.

**F. Waldorf:** A number of men suggested this morning that we all should begin to collect data and give it to the Industry for the benefit of the engineers of the future.

I have had several talks with Mr. Winne in which I outlined the need the roller bearing man has for accurate data on power requirements in order that he can interpret them into terms of roll neck pressure.

We never heard much of continuous strip mills except during the past six years. Prior to that there were strip mills rolling narrow widths and thin gauges, and we probably had some idea of the loads which were sent to the roll necks in such mills. But when it came to the modern four high hot strip mill, no information existed except what was gleaned from pressure tests made in a few two high stands. Such data usually found its way to the mill builder but the roller bearing man got little of it and had to ferret it out for himself.

The roller bearing builder must produce an article which, after all, is the life of the mill. If a bearing goes down and there are no spares on hand, one has to wait until another is made. Housings can be cast over night (figuratively speaking) and a few days later a plant can have something back on the job and be rolling. Roller bearings require time in building and it may be months before a replacement can be obtained.

At the outset the mill man looked to the mill builder for the proper roller bearing capacity. The bearing man had nothing to give. He had to start from scratch. The only thing he could do was to make pressure tests himself and by hook or crook get information on tests others had made and slowly, but surely, tabulate information which would enable him to approximate the loads his bearing must sustain.

As four highs went into operation and power data was obtained, we gradually gained access to the horsepower hours required per ton and in a way were able to check back and determine how far off we were in our original guesses as to neck loads.

Mr. Winne has today presented a paper which shows a number of curves. These are, no doubt, only a small percent of all he has, but he has given "something" and has placed you under the obligation of co-operating by collecting in return all the

data you can and sending it into the Association. In that way we can help each other in the future.

Having early obtained a copy of Mr. Winne's paper and read it, I feel that if someone were to make a start in that direction it would set the ball rolling and others would fall in line and publish data that would be of benefit to all.

The contribution I can make is something in regard to how we approach the neck load problem. This, after all, is a very important one. The roller bearings must carry all the load the motor can impose upon them. If they are not there with ample capacity failure will soon shut down a mill.

We are aware of some dozen formulas which have been advanced for calculating rolling pressures. Many engineers use only Fink's formula which involves the logarithm of the elongation to the base "*e*." But regardless of what method is used the results cannot be as accurate as those obtained by converting actual horsepower, obtained by test, into rolling pressure.

Since reading Mr. Winne's paper I have made a comparison between a number of formulas and find that many of them can be reduced to what might be called one fundamental which states that: rolling pressure times contact length times roll speed divided by 63025 gives the horsepower for deformation. Then, taking the horsepower hours per ton from Mr. Winne's curves, we can arrive at the horsepower rate from the rolling rate in tons per hour. This horsepower rate after being reduced by the amounts required for all losses besides that for actual rolling should be convertible into torque, or movement of force, in which the force will be the rolling pressure.

Whether or not this is entirely correct I cannot now state, but I can say this much: In the past six years, of the twenty 4-high hot strip mill installations which have come up for estimate and of which thirteen were built, I had the privilege of calculating the rolling pressures for sixteen that came up and for ten of those which were built. All of the mills built are rolling today.

It is true that there was some bearing grief to overcome, but since the bearings are still carrying the loads we must have hit the nail on the head.

I have never been able quite to reconcile Fink's formula to hot strip rolling because of the absence of data on pressures which were determined by it. I have, however, read where the stress for steel of about 1650 degree F. when used in this formula is assumed to be around 14,000 lbs. per sq. in.

The temperature of the steel entering the first stand in a four high installation may vary from 1800 degree F. to 1500 degree F. and the lowest pressure I have obtained by calculation is on the order of 30,000 to 35,000 lbs. per sq. in. For the finishing pass calculations based upon the horsepower sent to the work rolls show that the pressure will be around 135,000 lbs. per sq. in. This shows that the curve has an abrupt rise as the stock gets thinner and colder.

If the stress for the last stand is calculated by Fink's formula it is even higher and this emphasized the need of definite check by tests after the mills are in operation.

In the meantime, we must work from power curves or from pressure curves which are worked up from tests.

I would like to ask Mr. Winne if the horsepower hours/net ton given by his curves are the motor inputs. If they are, they must be corrected for all losses such as motor, drive, pinion and back up bearing friction before the horsepower left for deformation is obtained and rolling pressures can be calculated.

Mr. Winne mentions the important part temperature plays in the question of power for rolling. He also describes how he fixes upon the motor rating in order to provide ample overload capacity to take care of extreme demands.

Mr. Farrington told us about the uncertainty that a mill which is built to roll one thickness may not be called upon to roll considerably thinner stock and cites that where they originally intended to roll only to .065 they have already gone down to .04.

With conditions like that to meet, the bearing must be capable of handling anything. The thinner the stock rolled the higher the rolling pressure mounts.

I will work up something in the way of the analysis I have made of several methods for calculating rolling loads, and send it in for publication. I cordially invite others to fall in line and send in what data they obtain by test so that the Association can publish it and from it we all can learn.

**H. A. Winne:** Mr. Kenyon's point regarding the effect of temperature and analysis on power requirements is extremely well taken. What is seemingly a small change in temperature may double the power required. Too frequently in the past, in making power tests, temperatures have not been recorded as they should be; as a matter of fact it is desirable to take temperature following every stand, although this is not always possible. As far as the effect of analysis is concerned, I know of one particular case of rolling alloy steel in a continuous mill in which the first few passes required less power than for ordinary open hearth steel, while the final passes required about 50% more. This peculiar condition was due to a combination of differences in temperature and analysis.

I want to especially thank Mr. Hall for his kind remarks advocating that electrical manufacturers should be given all available mill data when they are asked to quote on drives for rolling mills. When you try to work through one of these calculations you will see how essential it is that the information given should be complete. Mr. Farrington's remarks serve very well to emphasize that particular fact. Incidentally, he will undoubtedly remember that I had to fight—not him, by the way—to get those two motors as big as they are.

Answering Mr. Waldorf, the power readings given under "HP per pass" do not include motor losses, but do include roll neck friction losses.

Mr. Standing mentioned the motorizing of old steam driven mills. It is a peculiar fact that it always seems about ten times as difficult to get complete rolling data on an old steam driven mill as it does to get it on a proposed new mill. Very often the information that can be obtained is so meager that about all that can be done is to make an "educated guess." We cannot make accurate calculations without complete and correct information to start with.

# Coming Meetings and Papers

## ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

### CHICAGO DISTRICT SECTION

W. A. PERRY, Chairman — A. J. WHITCOMB, Secretary

INSPECTION TRIP

INLAND STEEL COMPANY, INDIANA HARBOR, IND.

THURSDAY, OCTOBER 20, 1932, AT 2:00 P. M.

MILLS TO BE INSPECTED:

NEW 76" CONTINUOUS HOT STRIP MILL.
NEW 10" CONTINUOUS MERCHANT MILL.

Members and Visitors Will Assemble at 2:00 P. M. at Plant No. 2 Gate Across the New York Central Tracks Near the Lake Front.

SCHEDULE OF TRIP

2:00 P. M.—New 76" Continuous Hot Strip Mill. New 10" Continuous Merchant Mill.
5:30 P. M.—Dinner at Phil Smidt's on Indianapolis Boulevard. Price $1.00.
7:00 P. M.—A descriptive paper covering the interesting and novel features of the mills which were inspected. Discussion to follow and questions will be answered.

PLEASE NOTE:
Make your reservations for the Inspection Trip and Dinner to W. A. Perry, Supt., Elec. & Pwr. Depts., Inland Steel Co., Indiana Harbor, Ind.

### PITTSBURGH DISTRICT SECTION

J. W. BATES, Chairman — J. I. KASPARI, Secretary

BLUE ROOM, WM. PENN HOTEL — PITTSBURGH, PA.

SATURDAY, OCTOBER 29, 1932, AT 7:30 P. M.

"APPLICATION OF SYNCHRONOUS MOTORS TO MAIN ROLLS IN STEEL AND NON-FERROUS ROLLING MILLS"—S. P. Bordeau, Electric Machinery Mfg. Company, Minneapolis, Minn.

### PHILADELPHIA DISTRICT SECTION

C. M. THOMPSON, JR., Chairman — L. O. MORROW, Secretary

ENGINEERS CLUB — PHILADELPHIA, PA.

SATURDAY, NOVEMBER 5, 1932

"FUNDAMENTALS IN THE DESIGN OF OIL CIRCUIT BREAKERS AND THEIR APPLICATION TO PRESENT DAY BREAKERS"—D. C. Prince, General Electric Company, Philadelphia, Pa.

"OIL BLAST CIRCUIT BREAKERS (TALKING MOTION PICTURE AND MODELS)"—E. B. Merriam, General Electric Company, Philadelphia, Pa.

"BASIC REASONS FOR METAL ENCLOSED SWITCHGEAR AND PRESENT DAY DESIGNS"—R. Paxton, General Electric Company, Philadelphia, Pa.

### CLEVELAND DISTRICT SECTION

A. L. FOELL, Chairman — W. W. SPANAGEL, Secretary

CLEVELAND ENGINEERS CLUB — CLEVELAND, OHIO

FRIDAY EVENING, NOVEMBER 4, 1932

"USES OF HEAT RESISTING, STAINLESS AND OTHER ALLOY STEELS AS APPLIED TO THE STEEL INDUSTRY"—Earl C. Smith, Chief Metallurgical Engineer, Republic Steel Corporation, Youngstown, Ohio.

### BIRMINGHAM DISTRICT SECTION

W. J. DONAHUE, Chairman — J. B. LOONEY, Secretary

SATURDAY, OCTOBER 29, 1932

"SHIELDED ARC WELDING"—John E. Durstine, Lincoln Electric Company, Birmingham, Ala.

(Continued From Page III)

Safety, Mechanical, Lubrication or Electrical Engineering Divisions of any one of the five sections (Philadelphia, Chicago, Cleveland, Birmingham and Pittsburgh) (of the Association of Iron and Steel Electrical Engineers. Naturally, it will be appreciated that all editorial matter is subject to the constructive criticisms, views and opinions of any engineer or operating superintendent present at the sectional meeting.

5. Articles and discussions originate with the men inside the plants and the mediums that are employed to bring this about are as follows:
   a. Technical sessions are held in five steel sections once a month (Cleveland, Pittsburgh, Philadelphia, Birmingham and Chicago.)
   b. Committee Meetings: Papers, Editing, Welding, Developments in Rolling Mill Practices, Reduction Gear Sets, Electrical Developments, Special Bearings, Standardization, Safety Engineering, Illumination, Portable Electric Tools, Shop Practice, Transporatation, Special Committee on Control, Switching, Electric Heat, Steam Generation and Utilization, Gas Producer, Liquid Fuel, Furnace Section, Instruments and Control, Lubrication and Engineering Practices.
   c. Inspection trips to industrial and steel plants. Practically every prominent steel plant in the United States has been paid a visit by the A. I. & S. E. E.
   d. A. I. & S. E. E. National Conventions.
   e. A. I. & S. E. E. Iron and Steel Expositions.
   f. Our personal contact with the engineers and superintendents in the Industry through membership of the A. I. & S. E. E.
   g. Through our firm membership of steel plants.
6. The major articles appearing each month deal almost entirely with fuel, mechanical, electrical, safety, metallurgical and lubrication subjects, having to do with the selection, installation, operation, maintenance and supervision of equipment used in the Iron and Steel Industry.
7. Articles, discussions, codes and specifications are prepared to solve the problems that confront the engineers and superintendents in their daily routine.
8. All the data appearing in the Iron and Steel Engineer is of a practical nature as it represents the experiences secured in the operating field.

**Editorial Structure.**

Over 100 Steel Mill Technical Executives, consisting of managers, superintendents, master mechanics, chief engineers, electrical engineers, mechanical engineers, lubrication engineers, combustion engineers and safety engineers, constitute the Editorial Structure of the Iron and Steel Engineer. (See September, 1932 issue of the Iron and Steel Engineer).

**Distribution.**

1. Exclusively a steel mill engineering and operating medium.
2. All steel mill centers in the United States and Canada.
3. Highly specialized due to the fact that we appeal to the "key" men only who are, as a rule, the electrical engineer or superintendent, chief engineer or master mechanic, combustion engineer, mechanical engineer or lubrication engineer, general superintendent, departmental superintendent or operating superintendent.

**Utility of Iron and Steel Engineer.**

ALL COPIES ARE MAILED DIRECT TO PLANTS and are used as

1. Reference value.
2. To check standards, codes, etc.
3. All modern mill drives are being continually checked as reference.
4. Used in conference at the plants to check engineering opinions expressed at technical sessions of the A. I. & S. E. E.
5. Charts, curves, drawings in the Iron and Steel Engineer reflect standard practices in the plants.
6. Detailed engineering descriptions of plant installations.
7. The only periodical in the Iron and Steel Industry which reflects engineering and operating costs.
8. Opportunities to compare results obtained in certain apparatus, materials and equipment.
9. Presents to Steel Mill Engineers and Operating Executives the most efficient methods and opinions on various subjects, thus eliminating many expensive tests or experiments by the individual company.
10. The engineer in the smaller plant profits by the experiences, tests and opinions of the engineer in a larger company having enormous facilities for making tests.
11. Enables engineers to present plans for improvements and back up arguments with concrete proof of their success in other plants.
13. Editorial is of a proven steel mill interest.

**Pertinent Points.**

The Iron and Steel Engineer prints the Standards, Codes, Specifications or Recommendations compiled by the Mechanical, Lubrication, Combustion, Electrical and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers and used by the Iron and Steel Industry, such as electric overhead traveling cranes, mill type motors, A. C. induction motors, practices on lubrication of cranes, motors, roll necks, gears, etc., main drive motors for rolling mills, specifications for ordering

gears, open hearth furnace control, guide forms, A. C. and D. C. control, main drive rolling mill motor guide forms, rules for protection of employees when working on high tension transmission lines.

The Iron and Steel Engineer presents in an unbiased manner to the combustion, mechanical, electrical, lubrication and safety engineers and operating superintendents of the Iron and Steel Industry opinions, views, data and details on selection, design, installation, operation and maintenance on all equipment used to process and produce Iron and Steel.

The Iron and Steel Engineer is the only periodical in the United States that prints the growth and expansion of all rolling mill drives, beginning with 1905 until the present date and includes the following types of mills:

1. Tube and Piercing Mills.
2. Rod Mills.
3. Bar and Billet Mills.
4. Strip Mills.
5. Structural Mills.
6. Merchant Mills.
7. Plate Mills.
8. Sheet and Tin Plate Mills.
9. Sheet, Bar and Skelp Mills.
10. Reversing, Blooming Mills.

Printed Monthly.

Advertised technical sessions arouse interest in subjects, which appears in later issues of the Iron & Steel Engineer.

# ITEMS OF INTEREST

## PERSONNEL CHANGES

▲

John A. Coakley, vice president of the American Steel & Wire Co., at Cleveland, in charge of traffic, has been appointed general traffic manager for eight subsidiaries of the United States Steel Corp., with headquarters at Pittsburgh, effective Oct. 1. For 33 years he has been identified with the American Steel & Wire Co., being traffic manager since 1921. In his new post, directing traffic for the American Steel & Wire, American Bridge, American Sheet & Tin Plate, Carnegie Steel, Illinois Steel, Lorain Steel, National Tube and H. C. Frick Coke Companies, Mr. Coakly will control what is probably the largest volume of freight traffic in the United States under the direct supervision of one man.

▲

George R. Roemer, formerly chief engineer for the Continental Steel Corp., Kokomo, Ind., and long identified with the sheet and strip industry, has established offices as industrial engineer at 47-49 West street, New York. Under an arrangement with J. I. Bernitz, New York, Mr. Roemer will sell the Ungerer sheet leveler, a German machine.

▲

Concluding forty-seven years in the employ of the General Electric Company and its predecessors, William S. Culver, district engineer of the East Central district of the company, with headquarters at Cleveland, retires from active duty at the end of September. By appointment of W. J. Hanley, commercial vice president in charge of the district, C. W. Fick, assistant district engineer, becomes district engineer to succeed Mr. Culver, effective September 30.

▲

SKF Industries Inc. of New York, supervising The Skayef Ball Bearing Company of Hartford, Connecticut; The Hess-Bright Manufacturing Company, Atlas Ball Company, and SKF Research Laboratory, of Philadelphia, have announced the consolidation of the manufacturing activities of The Skayef Ball Bearing Company of Hartford with The Hess-Bright Manufacturing Company, at Philadelphia.

▲

Louis E. Underwood, managing engineer of the stationary motor engineering department of the General Electric Company at Lynn, Mass., has been appointed manager of the Pittsfield, Mass., works of the company to succeed E. A. Wagner, who has retired.

▲

Appointment of G. E. Tenney as sales manager of the Chicago district, is announced by The Lincoln Electric Company, Cleveland, Ohio.

Previous to joining the sales staff of the Lincoln organization, Mr. Tenney was engaged in shop, engineering and sales work for the Houghton Elevator Company, Toledo.

▲

Elliott Company, Pittsburgh, Pa., and associates The Lagonda Mfg. Company and Liberty Mfg. Company announce the removal of their Baltimore district office to Washington, D. C. The new address is 918 Washington Loan and Trust Building, 9th and F streets, N. W. Mr. H. C. Hale is district manager. Mr. C. H. Russell remains in Baltimore at 3602 Calloway Avenue, as resident sales engineer.

▲

## WITH THE MANUFACTURERS

▲

The Falk Corporation, Milwaukee, Wisconsin, announces three styles of Motoreducers (combined motor and speed reducer) which represent a distinct departure from previous practice.

These Motoreducers retain all the advantages of separate motors and speed reducers and, at the same time, give increased compactness, simplicity and economy.

The gear housing in every case acts as a support for the motor, thus assuring the necessary rigidity.

A bulletin has just been issued covering sizes, dimensions, specifications, method of selection and

other engineering data. Write The Falk Corporation, Milwaukee, Wis.

▲

The American Air Filter Co., Inc., at Louisville, Ky., have issued their bulletin No. 270 which describes the Turbo-Clone Dynamic Precipitator.

The Turbo-Clone Dynamical Precipitator is an entirely new and unique development for conveying and collecting process dust. It is in reality a combined blower and dust collector condensed into a single machine, but should not be confused with dust collecting fans, from which it differs both in principle and performance. In appearance it looks very much like the conventional heavy duty blower fan, but an examination of its structural details, particularly the impeller, will show how it gets the name, dynamical precipitator.

The impeller, which is the only moving part of the Turbo-Clone, consists of a specially designed steel disc supporting a multiplicity of hyperboloid blades. The unusual shape of these blades when rotated create the necessary forces to draw in the dust laden air, separate and precipitate the dust and expel the cleaned air.

The Type "D" Turbo-Clone described in this bulletin is a single stage machine capable of producing a suction or pressure up to 20" water gauge. Its efficiency in dust removal ranges up to 99.5%, depending upon the nature and concentration of the dust. For higher pressures or efficiencies, two or more Type "D" Turbo-Clone may be operated in series or a multi-stage machine can be furnished.

The Turbo-Clone is particularly well suited to dust of gritty or granular structure. Because of its compact design, it may be installed at or near the source of the dust and thus eliminate expensive pipe lines or duct work. It is a complete self-contained unit, either direct-connected or belt-driven by a motor of the proper size and speed, and may be mounted directly above a suitable hopper for collecting the dust.

A copy of this bulletin will be furnished by writing American Air Filter Co., Inc., Louisville, Ky.

▲

The Electric Controller & Mfg. Company issued their new bulletin No. 900 which describes the E. C. & M. Lifting Magnets. This bulletin describes many changes and additions the most important of which are:

1. The use of Dardelet Self-Locking through bolts for holding the inner and outer pole shoes on all sizes of Type SA Magnets.
2. An outer bottom plate of heavily ribbed construction to provide greater strength for diverting the hammer blows from the coil to the heavy magnet case.
3. Lifting capacities, weights, etc. on the new No. 3½ Type SA Magnet, a new size which is 39" in diameter.
4. Complete information on the greatly improved new EC&M Automatic Discharge Magnet Controller.
5. Illustrations and descriptions of the new Cable Connectors now regularly furnished with all sizes of EC&M Type SA Magnets.

A copy of this bulletin may be obtained by writing the Electric Controller & Mfg. Co., Cleveland, Ohio.

▲

A new mechanical-drive, noncondensing steam turbine for driving centrifugal pumps, fans, and other rotating equipment has been developed by the General Electric Company. This turbine is suitable for driving equipment at speeds from 1200 to 4000 rpm and is available up to 250 hp. under suitable steam conditions. The new turbine is a single-stage machine with two rows of revolving buckets. Simple in construction, it is an addition to the standard line of General Electric mechanical-drive turbines. The wheel casing is split horizontally to allow easy access to the internal parts and the steam and exhaust pipes are connected to the lower half of the machine. A centrifugal governor, with weights pivoting on knife edges, operates with very little friction and provides proper speed regulation. An independent emergency governor is included. The new turbine bears the type designation D-59 and, except for being larger, is similar to the type D-57.

▲

The Lincoln Electric Company at Cleveland, Ohio announces their new welder called the New Lincoln Arc Shield Welder. The new welder is rated 40 volts instead of the former 25 volts. As a result of this new design, it is claimed that it has been possible to eliminate the necessity of stabilizing or kick transformer of any nature. The new welder is also equipped with dual control.

▲

The Newport Rolling Mills, Newport, Kentucky, have just placed an order with Surface Combustion Corporation for a Walking Beam Sheet Normalizing Furnace. This furnace incorporates the hydraulic drive mechanism (Patent Applied For) which has been developed by Surface Combustion Corporation. Natural gas will be used.

▲

A new catalog of industrial lighting equipment has just been announced by the Westinghouse Electric and Manufacturing Company. This publication describes each unit plainly and lists them in a manner easy to find. A complete line of equipment is listed including new units, low priced industrial floodlights, quick change Wemco reflectors and sockets.

Copies of the catalog may be obtained from the nearest district office or direct from the advertising department, East Pittsburgh, Pa.

▲

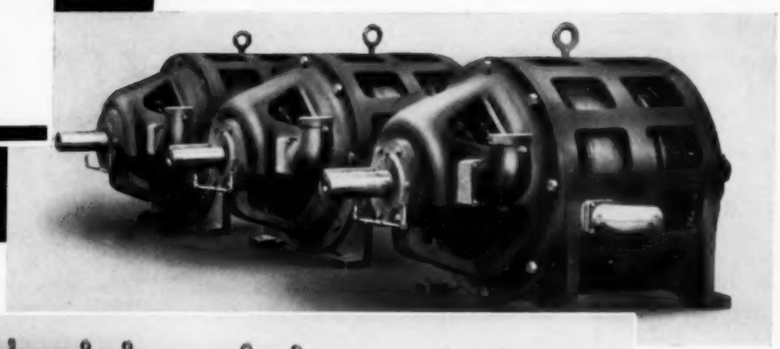
Cutler-Hammer, Inc., Milwaukee, Wisconsin, announce the development of a simplified system of control for operating electro magnetic clutches and brakes applied to punch and forming presses. The control incorporates patented safety features, which it is claimed insure the safety of the operators, and give the flexibility that should help obtain the maximum output.

The patented safety feature is a plurality of palm operated push buttons, mounted directly on the slide

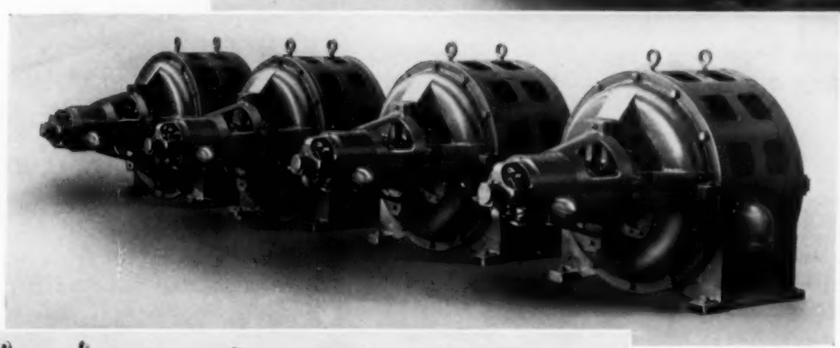
# ELLIOTT MOTORS

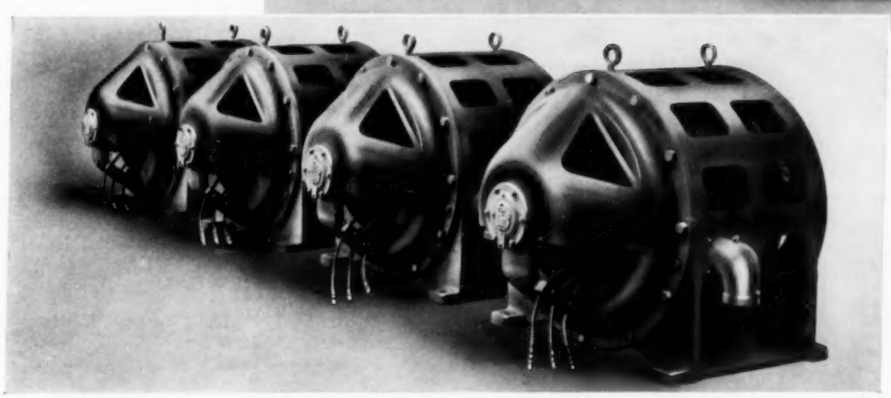
## are built to fit the job

*Three Elliott 250-hp., 1160-r.p.m. wound-rotor induction motors.*



*Two 500-hp., and two 350-hp., 1200-r.p.m. synchronous motors with direct-connected exciters.*





*Four Elliott 250-hp., 725-r.p.m. wound-rotor induction motors.*

Elliott motors are designed and built completely for the particular application by engineers who know, with none of the restrictions in design common to quantity production methods. Thorough tests on each motor, based on the service it is expected to give, add further to the user's security.

In large high-speed motors particularly, Elliott engineers have exceptional experience. They have achieved remarkable results in many difficult applications. Often after careful investigation of an electric drive problem, Elliott engineers have been able to suggest a better solution than that of usual standard practice.

Ask us for full details of Elliott Motors . . . and depend upon Elliott co-operation in meeting your most difficult drive conditions.

L-679

ELLIOTT COMPANY
PITTSBURGH, PA.
*Electric Power Dept.*
RIDGWAY, PA.
*District Offices in Principal Cities*

of the press. This insures that each hand of each operator will be occupied in holding a button depressed and consequently free from the press when the slide is descending to the bottom of the stroke.

Flexibility of control is obtained by providing three additional methods of operation with simple means of transfer to any one of the four methods desired. When transferred to the inching method of operation, the press will operate as long as the inch button is depressed, and will stop when the button is released regardless of the position of the slide. It is claimed that the control permits spotting to an accuracy of 1/32". When an automatic feed mechanism is employed, the control may be set to run the press continuously. The control can also be set to take the slide through one complete cycle by momentarily depressing the run buttons. Transfer to any method of operation is made on snap switch type transfer switches. A stop button is used for the purpose of stopping the press in case of an emergency.

Mill type switches rated 100 amperes are used for controlling the coil circuits of the clutch and brake. Control relays have been eliminated and electrical interlocks kept to a minimum. Unbreakable type resistors are mounted in the top of the enclosing case.

▲

The Trumbull Electric Mfg. Co., Plainville, Conn. have announced the addition to their "R. B." Industrial Switch line of the 30, 400, 600 and 800 Ampere sizes, making available a complete line of "R. B." switches 30 to 800 Amperes inclusive 2, 3 and 4 pole, 230 and 575 V. A. C. both side and front operated.

This new line 30 Amp. 575 V. A. C. to 800 Amp. 575 V. A. C. inclusive features a "vystipe" fuse clamping device which reduces heating at fuse terminals to a great extent (more than 50% over standard ferrule fuse clips), and also on the new sizes a new type of roll contact which maintains perfect line contact under heavy pressure which actually improves with use and eliminates the maintenance problem.

Circular No. 99 describing this line in detail sent on request.

▲

The Norma-Hoffmann Bearings Corporation Stamford, Conn., announces an addition to its extensive line of "Precision" Bearings in its type "CD" Duplex double angular contact ball bearing. This unit has been developed to meet the need for a bearing adapted not alone for radial loads but also for high thrust loads in either direction, with a width no greater than that of a standard single-row ball bearing. The "CD" outer ring is made in two parts; and both inner and outer raceways are ground to a special curvature suitable for safely carrying heavy end thrust. A one-piece ball retainer of extruded bronze rides, or is carried, upon the ground flanges of the inner ring. The "CD" Duplex Bearings are available in the light, medium, and heavy metric series in a range from 10 m/m to 100 m/m bore. They should be used only where the thrust load exceeds the radial load; and the duplex outer ring should be clamped tight in the housing.

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## ASSOCIATION NOTES

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The Chicago District Section held their Fall Golf Tournament at the Lake Hills Country Club, Wednesday, September 21st. It was attended by 85 persons. The following were the winners of the prizes:

First prize for Active Member: W. J. Rannells, Illinois Steel Co.

Second prize for Active Member: F. A. Wiley, Wisconsin Steel Works.

Third prize for Active Member: H. W. Neblett, D. H. Skeen Co.

Fourth prize for Active Member: E. O. Austermiller, Wisconsin Steel Works.

Fifth prize for Active Member: A. C. Nicholson, Illinois Steel Co.

First prize for Associate Member: R. E. Bock, Clark Controller Co.

Second prize for Associate Member: E. C. Otto, Crouse-Hinds Co.

Third prize for Associate Member: J. D. Kinsey, Cleveland Worm & Gear Co.

Guest prize: K. Bedell.

Mr. A. A. Piper, District Manager, Electric Controller & Mfg. Company, Chicago, Ill. made a hole-in-one at the Lake Hills Country Club, Saturday, September 17th. The hole-in-one was made on the 15th hole, the distance is 127 yards. Other members of the foursome were Messrs. Smith, Wiley and Austermiller.

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**STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF**

**IRON AND STEEL ENGINEER**

(Required by Act of Congress of August 24, 1912)

Name of Publication: Iron and Steel Engineer, published monthly at Pittsburgh, Pa. (Report October 1, 1932).
Editor—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Business Manager—John F. Kelly, Empire Bldg., Pittsburgh, Pa.
Names and addresses of stockholders holding 1 per cent or more of total amount of stock: None.

**Board of Directors**

President, J. D. Donovan, Republic Steel Corp., Canton, Ohio.
First Vice President, W. E. Miller, Bethlehem Steel Company, Johnstown, Pa.
Second Vice President, W. H. Burr, Lukens Steel Company, Coatesville, Pa.
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Honorary Director, James Farrington, Wheeling Steel Corp., Steubenville, Ohio.
Known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities: None.

JOHN F. KELLY, Editor.

Sworn to and subscribed before me this 27th day of September, 1932.
HENRY W. BALDWIN, Notary Public.
(My commission expires April 16th, 1933).